DEVELOPMENT OF STRATEGIES OF TEACHING PHYSICAL SCIENCE AT SECONDARY LEVEL

REPORT OF THE PROGRAMME HELD AT
REGIONAL COLLEGE OF EDUCATION, BHUBANESWAR
During SEPTEMBER 1-7, 1993

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FOREWORD

In the context of school education it is felt that the teachers learn their content in academic institutions and learn pedagogy in educational institutions and adopt age old practices of teaching in the classrooms. For qualitative improvement of teaching in our schools as envisaged in the National Policy of Education, 1986, it is imperative that the theories of teaching and researches in science education must find their rightful representation/manifestation in prevalent teaching practices in the classroom. It is with this end in view the programme of Development of Teaching Strategies for Teaching Physical Science at Secondary Level was organised in the college for the teachers and teacher educators of Orissa and Bihar during September 1 - 7, 1993. The methodology adopted in this programme was on the whole of participatory nature and I am pleased to hand over the academic report of this programme to all those who are interested in the teaching of physical science at secondary level. I congratulate the resource faculty and the participants for their sincere efforts to produce this report for all of us to see its utility and dissemination.

KC Panda

(Prof. K.C. Panda)
PRINCIPAL

PREFACE

National Policy of Education 1986, while acknowledging the spread of secondary education in the country lays special emphasis on the qualitative improvement of education in general and science education in particular. A centrally sponsored Scheme for Improvement of Science Education in Schools (SISES) was introduced for this very purpose. Apart from the improvement of laboratory and other facility the scheme envisaged strengthening of inservice teacher training component. The programme of 'Development of Strategies of Teaching Physical Science at Secondary Level' was organised in this connection. Dr.V.G. Jadhao, the Programme Director in consultation of the faculty of the science department planned this programme to initiate the teachers and teacher educators of the region to evolve the strategies for teaching physical science by active participation through discussions and study of the national and international efforts in this direction. The resource faculty comprising of the members of the staff of Physics and Chemistry sections have given commendable account of their hold on the content and methodology of teaching various topics as detailed out in the present report. The participants have also worked very hard to develop the write-ups on various topics. I hope this will be found useful in actual classroom situation and look forward for its wide use and constructive criticism to guide us in our future efforts at organising similar programmes.

Khattar
Professor N. Khattar
Head of Science Department

ACKNOWLEDGEMENT

I am grateful to cur Principal, Prof.K.C.Panda, and Head of the Science Department Prof.N.Khattar for providing me their guidance and help in organising this programme as Programme Director. I also wish to record my sincere thanks to the Coordinator, Dr.J.K. Mohapatra for academic and logistic support in all the matters of organisation of the programme. I wish to give special thanks to Shri M.A. Chandrasekhar In Charge of Physics Section for his encouragement in general and for introducing me to word-processing on computer which helped me a lot in preparing this report. In this connection I would also like to thank In Charge of Computer Cell, Dr. K.K. Chakravarti and Project Fellow Shri Rajanikant Mohanty for bearing with my work schedule and making the computer facility available to me at all times. I thank all my colleagues from physics and chemistry section for their all out support as resource persons at all the stages of this programme.

I would like to record my thanks to all the staff members of Science Department, Extension Department, Audio-Visual Department, Accounts Section, Wardens of the various hostels, and our Librarian Mr. R.N.Rath for their timely help in related matters.

Lastly, while owning the responsibility for the errors of commisionnand ommision in this report, I thank all the participating teachers and teacher educators of Orissa and Bihar for making this programme and this report what it is !

Jadhao
(Dr. V.G. Jadhao)
Programme Director

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BRIEF REPORT BY THE PROGRAMME DIRECTOR

Under the auspices of National Council of Educational Research and Training (NCERT), Regional College of Education, Bhubaneswar, organised a programme for 'Development of Strategies of Teaching Physical Science at Secondary Level' during September 1- 7, 1993 in the College for the Teachers and Teacher Educators of Bihar and Orissa. Out of the expected 20 teachers and 10 Teacher Educators 11 teachers and 7 teacher educators attended this programme. Out of these 8 teachers and 6 teacher educators came from Orissa and 3 teachers and 1 teacher educator came from Bihar. So as a whole turnout was 60% and both states as well as both categories of participants were well represented.

At the outset the participants were accorded welcome by the programme director and he also introduced the functionaries on the dias and the resource persons. Participants then introduced themselves describing in brief the work they do in their institutions. After this the programme director stated in brief the objectives of the programme as: i) Providing to the teachers and teacher educators of the region an opportunity to share and critically analyse their views on the content and methodology of teaching physical science at secondary level, ii) developing some exemplars on some selected topics of physical science and iii) recommending some general guidelines for teaching physical science at secondary level. The Coordinator of Extension Department, Dr.J.K.Mohapatra in his terse observation stated the interplay between the research in science education and the teaching practices adopted in the classroom. The programme was formally inaugurated by Prof. and Head of the Department of Science, Dr.N.Khattar. In his inaugural address Prof. Khattar referred to the National Policy of Education, 1986, and emphasised the role of teacher in its implementation and hoped that this programme will go, a long way in initiating the teacher and teacher educators in construction of pedagogical part of the physical science curriculum at secondary level and thus supplement the efforts made under the Scheme of Improvement of Science Education in Schools (SISES). Dr. S.K.Mohapatra, In Charge of Chemistry section proposed the vote of thanks to the educational authorities of the Government of Orissa and Bihar, to the participants, to all members present in the inaugural function, and to the staff members of Extension and Audio-visual Departments and wished that the participants will have a nice stay and will do meaningful work.

Four sessions comprising 12 hours were devoted on: i) the threadbare discussion on objectives of the workshop as outlined in the approach paper clarifying the meanings of the terms like strategy, approach and skills, ii) discussion on relevance and inclusion of alternative frameworks of pupils as a necessary pedagogic input from the researches conducted in this area, and iii) discussion on the specific teaching strategies exemplified by the resource persons in their presentations on some selected topics. After this the participants arrived at a commonly agreed proforma for development of exemplars in topics selected by them on the basis of the proforma suggested in the approach paper. All the participants were provided with necessary literature on teaching of physical science at secondary level from the rich library of the college. Shri Madhusudan Mohanty one of the teacher educators accepted the responsibility of preparing the draft of general guidelines on the basis of the discussion held in the programme and the literature provided for developing the exemplars.

Remaining 8 sessions comprising of 24 hours were utilised by the participants for working in four groups to develop exemplars on 12 topics of physical science selected by the participants. These topics were: i) Composition of Air, ii) Wave motion, iii) Other Sources of Energy, iv) Refraction of Light, v) Chemical Bonding, vi) Structure of Atom, vii) Force and Acceleration, viii) Gravitation, ix) Oxidation-Reduction Reaction, x) Ohm's Law Verification, xi) Magnetic Poles and xii) Concept of Work.These exemplars followed by a Bibliography form the third chapter of the detailed report of which this report is the first chapter. The second chapter consists of the presentations of the resource persons on the content and methodology of teaching some specific topics as well as on the importance of alternative framework in teaching physical science. The Annexures contain the approach paper by the Programme Director, the draft of general guidelines for teaching of physical science, the list of participants and resource faculty, and the programme and evaluation sheet.

Prior to the valedictory function evaluation of the programme was done on following 12 aspects of the programme which are listed along with average response of the participants as follows:

	ASPECT	RESPONSE (in terms of % of participants stating the aspect as adequate or more than adequate)
i)	Discussion on Approach paper	95
ii)	Content Coverage	90
iii)	Methodology coverage	85
iv)	Opportunity for free Discussion	95
v)	Time alloted for development of exemplars	85
vi)	Duration of the programme	50
vii)	Resource Material provided	85
viii)	Physical Facilities	100
iv)	Suggestion for venue for future	important places of Bihar and Orissa
x)	Concepts learnt better	All concepts taken up by Resource faculty.
xi)	Approaches useful for teaching physical science	Majority preferred environmental and logical approaches, other approaches like child centered, huristic, science-for-all and so on were mentioned.

xii) Referred literature	Modular Secondary Science Resources and PSSC(Physics) were referred in majority of cases and all references listed in Bibliography are mentioned at least once.

In the valedictory function the programme director presented the brief report of the programme incorporating the response of the evaluation sheet and stated his observation on group work that although in general it was quite vigorous some participants needed improvement in this regard. Dr.J.P.Sharma, Teacher Educator from Bihar and Shri Purna Chandra Rath, Shri H.N. Mishra teacher from Orissa, and Shri Arun Kumar, teacher from Bihar expressed the reactions of the participants as their representatives. In generall there was a sense of satisfaction and they wished this programme could be for 15 days. Professor Khattar in his trite remarks expressed that he is happy if all are happy and hoped that the academic report of this programme would reach the participants in due course of time. Our Principal Professor K.C. Panda gave the valedictory address, wherein he said that for qualitative improvement of teaching in schools it is essential for the teacher to know more content as well as methodology. He stressed the importance of process approach of teaching science and hoped that the work on integration of content and methodology initiated in this programme would be useful and can be extended. Dr.J.K.Mohapatra proposed the vote of thanks to one and all and urged the participants to take this as a beginning and continue this work of meaning what you say and, saying what you understand in their respective classrooms.

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PUPILS' ALTERNATIVE CONCEPTIONS

Dr.J.K.Mohapatra,
RCE, Bhubaneswar

After Ausubel's profound statement -

- the single most important factor determining the degree of learning of a pupil is the concepts that the child carries with him/her into the classroom; ascertain them and teach him/her accordingly. -

There has been a spate of research to diagnose, map, analyse and understand pupils' alternative conceptions about concepts in science. Some of the conclusions arrived at due to this intensive and extensive research are the following; -

a) No child enters a class devoid of personal constructs.

b) In most of the cases these personal constructs are different from those of the formal science.

c) They strongly affect the degree of learning.

d) They offer resistance for modification or erasement.

e) In many cases the personal construct of each child for any particular concept is different from that held by any other child.

At this point few examples of these personal construct i.e. alternative conceptions of the pupils are in order.

Example-1: The pupils are shown a glass full with water and a brass sphere and are asked-if this brass sphere is hopped into the water what will happen ?

The responses were collected in two phases. Firstly, the straight answer to the question as given by each pupil is recorded. Secondly, each pupil is engaged in a discussion and effort was made to have a peep into the reason for him/her giving the particular answer. At the end, compilation of the responses showed that there are four types of answer in the framework of the reasons given.

Answer-1.1: If the ball is dropped into the water nothing will happen to the level of water.

Reasons given: "We have seen at home that in the early morning our mothers pat spoons of sugar in to cup of tea, but nothing happens to the level of tea. Tea is a liquid, water is a liquid, and sugar is a solid that is heavier than tea, brass is also a solid heavier than water".

Comments: It is worthwhile to note here the logical way (in the pupil's frame) the pupil tries to justify his/her answer. The approach has enough similarity with the approaches of Scientists in explaining their observations. However, the mistake the pupils commit is that they try to extend their observations about particular event to a different eve which appears to be similar to the first one. Infac t, they advance arguments to justify the similarity of the two events. We call this process as "Conceptual Extrapolati

Answer-1.2: If the brass ball is dropped into th water, the level of water will go down.

Reasons given: "When we go back home and sit o the couch it gets squashed because we are heavier than the couch. Sinc the brass sphere is heavier than w so the water will also get squeez and the water level will go down".

Comments: This is again a case of conceptual extrapolation and the arguments advanced by the pupils appear to be good enough in the pupil's frame of reference.

Answer-1.3: If the brass ball is dropped into the water, nothing will happen to the level of water.

Reasons given: In this case, though the answer given is the same as that in Answer-1.1, the reasons put forward were totally different, "Sir ! we leave near a sea port. Daily so many ships come to the port. They are huge objects made of steel. But nothing happens to the level of water of the sea. So nothing should also happen here".

Comments: This answer is an excellent example of pupils' alternative conceptions generated through the experiences gathereed from the environment.

Answer-1.4: Water will flow out from the glass.

Reasons given: When this answer was given we were a bit happy as it conformed to our expected response. But the reasons advanced by the pupils were totally unexpected. "Sir! water has to over flow because we have seen that when mummy puts us in the bath tub water flows out from the tub".

Comments: This response is again an example of manifest alternative conceptions generated through life centered experiences.

The above example indicates that the pupils generate their own knowledge based on their own alternative conceptions created through multidimensional experiences. The second example given below is an example of a different type where the pupils logically apply what they have learnt in the class and arrive at an answer which in contradiction with the formal science concepts.

Example-2: As a pencil -on- paper test, a list o terms were given to the pupils and th were asked to tik the terms which describe living beings. One of the terms in this list was "Fire".

Answer-2.1: About 70% of the pupils answered that "Fire" is a "living being".

Reasons given: "Fire is a living being because;

a) Fire can move from one place to an
b) Fire can reproduce fire.
c) Fire needs food in the form of dry wood, leaves etc. for its survival
d) Fire breathes oxygen. Without oxygen fire dies.
e) Fire reacts in the form of sparks when there is stimulus in the form of beating it with a stick.

Thus fire possesses all the character stics of a living being and hence is a living being".

Comments: The arguments clearly shows lacunae in the drafting of our text book and the teacher's ignorance that the knower constructs his/her knowledge. The teacher is not to teach but help the pupil to learn himself. In that sense the teacher has to be a facilitator.

At this stage let us take an example from chemistry.

Example.-3: The pupils who were tested have already been taught "Physical change", "Chemical change" and "Oxidation", "Reducation". They were asked a very simple question; - "The gain in mass of an iron nail due to rusting is a Physical change or a chemical change?"

Answer-3.1: More that 70% answered that it is a physical change.

Reasons given: When engaged in a group discussion they voiced that since mass is a physical property of a substance any change in it has to a physical change.

Comments: The condept of "mass" has been ingrained in them in the frame work of its form and focus as taught in physics. This conceptualization is so strong that whenever they encountered an event dealing with mass they immediately conclude it to be a physical event.

This physicality of a concept in the domain of comprehension of the pupils is made more apparent in the following example. This example also involves "mass" but in a different context.

Example-4: The pupils are shown two bags, one containing potatoes and the other brinjals. They are asked to find out the mass of each bag using a beam balance. They found out that each bag weighs exactly 1 Kg. Then they are asked - "Which bag is the heavier one?"

Answer-4.1: More than 50% of the pupils answered that the bag containing the potatoes is the heavier one.

Reasons given: The bag containing the potatoes must be the heavier one because potato is so dense and brinjal is so floppy.

Comment : This is a very interesting illustration. The pupils have their o concepts about the term "heavy" and "light", which they have acqui from hearing such statements in daily life as - "this stone is ve heavy", "this iron bar is very heavy", "this piece of wood is ve light". They now apply these alter native conceptions to the situati stated above by totally forgettin their own experimental finding th both the bags weigh exactly 1 Kg.

An example of a different type is the following concerning the laws of reflection of light.

Example-5: We know that the law of reflectio states - Angle of incidence is equ to angle of reflection. The pupil were asked - Is this law valid in the case of reflection from a spherical mirror ?

Answer -5.1: More than 80% of the pupils answe "No" .

Reasons given: In most of the cases the pupils who gave the answer "No", failed to give any reason for such an answer. But few of them said that the law is valid in the case of reflection only from a plane mirror.

Comments: It was worthwhile to search for t cause of such an answer and the associated reasoning. What final was obtained is the following.

> In the book law of reflection is explained by using diagram of a plane mirror. In the practicals the pupils verify laws of reflection by using only plane mirror. So it has been induced in their mind that law of reflection is valid in the case of reflection only from a plane mirror. This we call the process of "Induced incorrect generalization".

The research journals are full of many studies on pupils alternative conceptions in specific concept areas. The results of these investigations show that the alternative conceptions rarely have a culture-bias or geographical boundary bias. Further, even under the best of teaching - learning climate, i.e. with the best of teachers, best of physical facilities, best of laboratories, best of text book and resource materials, the pupils do possess similar alternative conceptions which greatly control the degree of learning of the pupils.

Then the question arises - Under these circumstances what the teacher will do? If this is the actual situation what strategy the teacher will follow to teach science? Of course, the most important step is that the teacher must recognise the fact that pupils have alternative conceptions which greatly determine the degree of learning. He should no longer live in the hypothetical framework that he is the source of all knowledge and the pupils job is to receive it from him. He should realise that the pupils will receive what they feel is worth receiving and that too in a form that their alternative conceptions permit. In this framework we suggest the following strategy consisting of five different steps.

STEP-1: The most important step is that the teacher must identify pupil's alternative conceptions. To do this he must generate such an atmosphere in the class as to encourage each pupil to Voice his/her alternative conception in the specific concept domain which the teacher has planned to teach. This is a difficult ste for implementation. Because, a pupil will rarely voice his alternative conceptions due to (a) The fear that may be reprimanded by the teacher, (b) the apprehension that he may be ridiculed by his classmates and (c) the assumption that teaching can still go on even if he does not proffer a statement. One of the best techniques to create a conducive atmosphere is to divide the clas into groups and engage them in inter-grou discussions.

STEP-2: Once the alternative conceptions have bee identified then he has to locate the zone of Overlap between the alternative conceptions and the concept he is going to teac. This is necessary, because only then he can decide whether the alternative conceptions can be absorbed, or may be modified or should be totally erased.

STEP-3: Then he has to generate Interaction betwe the pupils, between the pupils and himsel so that the pupil himself realises whethe his personal constructs can be absorbed o needs modification or should be erased.

STEP-4: Only then the teacher can proceed to engag the pupils in such activities as to hel them to learn the Concept. Designing of these activities needs all the expertise and ingeneuity of the teacher because the activities have to be new, interesting, absorbing and must have the inbuilt abil to arouse curiosity and to storm the bra

STEP-5: To leave a deep imprint of the concept i the minds of the pupils, the teacher th should Enunciate the concept with suitab examples.

We call this strategy - "VOICE" by collecting t irst letters of the key words of the above five ste

TEACHING OF CHEMISTRY AT THE SECONDARY LEVEL

Dr.A.N.Gupta,
R.C.E., Bhubaneswar

Introduction

At the secondary level, although Chemistry is a part of the General Science syllabus even then it has special place as a separate discipline due to its correlation with other sciences like physics and biology. Without proper understanding of certain concepts of Chemistry it is not possible to clearly think about many physical and biological phenomena. This arises due to the fact that chemistry deals with the constitutition of matter belonging to a living or nonliving system. Hence it is essential for us as teachers to give a very clear and proper understanding of certain basic concepts of chemistry so that the pupils can apply them in other fields.

The Syllabus

The science syllabus of CBSE and other states as well includes the following topic coming under the domain of Chemistry:

i) The Nature of Matter
ii) Periodic Classification of Elements
iii) Chemical Bonding
iv) Chemical Reactions
v) Energy Changes in Chemical Reactions
vi) Chemistry of Carbon Compounds
vii) Chemistry of other Elements

The Strategy

The topics listed above form the basic core of both physical and biological scienes, and can be taught by adopting the methods/approaches:

i) Lecture Method
ii) Demonstration Method
iii) Making Use of Model and Charts
iv) Discussion Approach.

It is not advisable and proper to say that a particular topic should be taught by any specified approach. Depending on the concept involved and the inclination of the teacher any one or the combination of more than one approaches could be adopted. For example if one has to teach the topic on structure of matter he would prefer to use Charts and the commonly available materials around us to give the concepts involved. Classroom-discussions can also help the students in understanding this topic. Similarly Periodic classification of elements can be taught by using a serie of charts giving exhaustive information on the properties of elements. Normally we use only the periodic table which gives the symbol and atomic weight and atomic number but does not give any information on the properties of the elements which form the basis of the periodic classification. So some new charts should be prepared may be with the help of the pupils themselves. I am sure the pupils will enjoy this activity.

The topic on Chemical Bonding should be taught using models. These models can be prepared using plastic or clay balls and ordinary springs. Pupils can get a better idea looking at these models about geometrical shapes of different molecules and also they do not form wrong concepts like, say, methane is a plane molecule which it is not. This happens because we write structural formula of methane so many times on the plane of the blackboard. Wherever models are not possible charts could be prepared and used.

Chemical reactions and their rates form the very core of chemical and biological processes and their understanding is very important. This topic can be taught using some simple laboratory demonstrations, showing the effect of temperature and concentration on chemical processes. The topic on energy changes in chemical processes should also incorporate certain simple experiments.

The subject matter of organic Chemistry involves the study of carbon compounds with other elements such as hydrogen, oxygen and nitrogen. This topic can best be taught using charts and models. The molecules of the organic compounds have widely different shapes. These shapes cannot be explained unless we use three dimensional models. These models help pupils to understand more clearly the bond formation in organic compounds. Difference between single bond, double bond and triple bond can be clarified by using these models. We can involve our pupils in making the models and in this way pupils can own these models. Of course it is not possible to prepare model for the molecule of each and every compound, but it is possible to make them for some simple compounds having different functional groups as well as different types of bondings.

The last topic on Chemistry of other elements is an extremely descriptive subject matter and we have to cover this topic using only the lecture or lecture-cum-discussion method. These lectures can be illustrated with charts and models wherever possible. While giving these lectures appropriate use of the blackboard should be made to write the important points and draw line drawings of apparatus, structures and classifications. Finally, I would like to make it clear that there cannot be a definite rule for teaching any topic or concept and the teacher should have the necessary flexibility to choose the approach which he feels most appropriate. He is the best judge in this regard because he alone knows the facilities available in the school and also about his own abilities and the needs of is pupils. In spite of all this, our basic objective remain the same namely the development of the proper concept in the pupils, the sharpening of their abilities to apply these concepts in other streams of science and life itself.

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CONCEPT OF FORCE

Dr.V.G.Jadhao
R.C.E.,Bhubaneswar

Introduction:

The term "Force" is familiar to all of us in the sense that we use it in our day to day language while describing things and events happening all around us. For example we say water is coming out of the tap with great force; the police forced the door open; inspite of applying so much force the lid of the tin is not opening; the earth keeps us tied down to itself by its gravitational force and so on and so forth. As teachers we also use it in solving the problems on mechanics or when we teach it as a concept in physics at any level starting from class three onwards. It is so fundamental a concept in physics that it is discussed at all levels in any science curriculum in an appropriately modified form. At secondary level it is discussed in class IXth after the chapter on motion and along with Newton's Laws of Motion. In the discipline of physics force has a very clear-cut meaning which is at variance of its use in every day language which is biased by the Aristotalian way of thinking according to which state of rest was a most preferred state and therefore the state of motion even uniform motion must have some cause for it which can be construed as 'Force'. Naturally these ideas are contrary to the formal concept of force but these very ideas nevertheless persist with pupils and teachers of physics. That it is so was again demonstrated in this group of teachers and teacher educators by administering the question regarding the direction of force acting on the ball in the thought experiment suggested by Professor Osborne. For the sake of completeness it is appropriate to describe the thought experiment: we describe to the group a situation in which we take a perfectly elastic ball and allow it to fall as it would on a perfectly elastic floor in an evacuated chamber so that air resistance does not come into picture. Then we ask the group members as to what would happen. They would all say that the ball would travel up and down till all time to come. Then they should be allowed to have any query aboutthis situation. These queries should be appropriately answered without using the term force. After this following question can be asked. 'What is the direction of force acting on the ball at the instant when it passes any point between the floor and the topmost point of its journey in i) upward direction and ii) downward direction.

The Osborne experimet can also be utilised in a class room situation before or after the teaching as is found suitable by the teacher. Now in what follows we are listing the prevalent misconcepts about the concept of force, discussing its causes and the appropriate strategy for teaching the concept of force.

The Misconcepts:

A representative sample of the misconcepts related to Force are as follows:

1. Force is associated with the body till it remains in motion.
2. When a body is at rest the force acting on it is zero.
3. Force is always in the same direction as that of the velocity.
4. Centripetal and centrifugal forces both act on a body moving in a circle.

Now let us discuss their origin and methods to prevent them. When we introduce the concept of force the very first example that we teachers tend to give is that of a stationary object like duster or a piece of chalk and impress upon our pupils that it will remain so as long as we do not apply forde on it. So the pupil reverses the argument in his mind and thinks that as force is required to have motion in the object at rest wherever there is motion force must also be present there. He is further helped in forming this misconcept by our inability to show him such motions which do not require any steady force to act on the object to keep it in uniform motion because of the ubiquitous presence of the frictional forces in every situation involving the object. We should emphasise in giving the above example that force is needed only to change the velocit of an object and no force is needed to maintain its constant velocity. In every day life we do require a steady force to maintain constant velocity of our bicycle or moped in order to overcome the friction arising due to relative motion of two surfaces in contact. Fundamentally these are also the result of interaction between the atoms and the molecules of the two surfaces. This brings us to the crux of the problem. Force acting on any object in any situation is always the result of its interaction with another object as is implied by Newton's third Law of motion. This being the situation one cannot associate force with one object alonewhether it is at rest or in motion. A force may act on an object but the cause of that force is always external to the object. Naturally the directio of the force would then depend upon the location and the nature of the other object. This then takes care of the second misconcept. The third one arises because the pupil is unable to distinguish between two situations namely the object permanently at rest and the object momentarrily at rest. Whatever ideas he has regarding the object permanently at rest he carries them over to the object momentarrily at rest. To prevent this misconcept we have to let the pupil first master the concept of average velocity and the instantaneous velocity. This has been very well dealt with in NCERT textbook at senior secondary level. Here it would suffice to say that unlike position velocity of a body is linked with two instants to begin with and not just one instant. The displacement suffered by the body divided by the time interval between the two instants gives us the average velocity during the interval.

The mathematical concept of the derivative of a function then gives us the concept of the instantaneous velocity as limit of the average velocity as the time interval tends to zero. What holds good for the velocity also holds for acceleration. When we come across a situation which tells us that the velocity of an object is zero at some instant we must inquire what was its velocity just before that instant. If it was zero then the acceleration can be inferred as zero at that instat. If not then the instantaneous acceleration would not be zero though the instantaneous velocity is zero. Many such situations are fully covered in the thought experiment of Professor Osborne. One has to just ask the pertinent question. The last misconcept has to do with the concept of pseudo force which is postulated in order to be able to apply Newton's Laws of motion to the non-inertial or accelerated frames of reference where in fact the laws do not apply. The centrifugal force is the psuedo force experienced in the rotating frame of reference be it earth when it is called coriolis force or a turning car wherein it is experience as a force acting outward. In our teaching of circular motion we do not emphasise the fact that the centripetal and centrifugal forces are not independent types of forces. They are just the names given to the forces acting in certain well defined situations like a body having uniform circular motion. It is like calling the force acting on a body moving in a straight line as backward and forward force.

The Concept and Beyond:

The first and the foremost thing one should keep in mind while learning the concept of force is that there does not exist any definition of force independent of Newton's Laws of motion. The first law gives you the qualitative definition of force. It just tells us how to conclude from our observations on the body whether any force is acting on it or not.

If one finds that the momentum of the body is changing with time which is equivalent to saying that the body is having acceleration then some force must be acting on it. The second law quantitatively defines the force as mass times acceleration. This is known as Mach's Principle and is used to correctly understand the concept of force. The significance of the third law is much deeper than the action and reaction it talsks about. It states a very important characteristics of the force namely that forces always occur in pairs. When we are interested in the motion of only one body we may not consider the other paired force but it does exist. Thus the third law states that force is the result of the interaction between two bodies. Only few books at secondary level emphasise this fact.

Finally it can be said that force does not have any objective existence as many other things in the nature have, but it is just a mental construct created by Physics or the physicists to interpret the kinematic of a body. Acceleration being the kinematic concept Mach's Principle describes the concept of force in terms of it as mass times acceleration. That is that; nothing more, nothing less. That is why some physicists believe that force is a 'ghost' we no longer need. In lagrangian and hamiltonian formulation of classical mechanics indeed we do not need the concept of force explicitely. In place of that we have to use the expression for energy as the fundamental postulate. Even for predicting the position of a body under the action of a single force its aceleration is enough. Force does not give us any extra information. This novel exercise of recasting the problems of physics at school level in terms of energy rather than force can be undertaken by enthusiastic teachers. An humble beginning can be made with the physics problems at the secondary level. Following things have to be kept in mind while undertaking this task;

1) Kinetic energy of a body is taken as equal to half of its mass times the velocity squared as a fundamental postulate not to be proved.

2) When the acceleration is positive the change in kinetic energy will naturally be positive and when it is negative the change in kinetic energy would be negative. This is very challenging and if this can be done it will amount to a major curriculum construction in physics at school level similar to what we have seen in the subject of mathematics.

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PERIODIC TABLE AND PERIODIC PROPERTIES

Dr.(Mrs)N.Chhotray,
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The arrangement of elements in the form of periodic table is a systematic approach to the comparative study of some physical and chemical properties of all the elements discovered till now. It is really a problem to memorise the properties of such a great number of elements (110). So the necessecity of the classification of these elements becomes important.

The topic - the periodic classification of the elements and the periodic variation of some of their properties" generally dealt, in the classroom, with discussion method. The major points to be discussed are:

(i) The historical development of the periodic Law and the periodic table.

(ii) The concept of the periodic table and the periodic properties.

(iii) Discussion of the different portions of the long form of the periodic table.

(iv) Main features of the periodic table i.e. detailed study of the periods and groups.

(v) Periodic variation of some of the properties of the elements such as atomic radii, ionic radii, ionisation energy, electron affinity and electronegativity etc.

Concepts:

1) When the elements are arranged in order of increasing atomic number they show periodicity of electronic configurations.

2) The arrangement of elements in the form of vertical columns called "groups" and horizontal rows called "Periods" is defined as Periodic Table.

3) On the basis of electronic configurations, the elements can be classified into four blocks s -, p-, d-, f- block, depending on the nature of the atomic orbital into which the last electron enters.

4) Depending on the number of incomplete shells of electrons in the atom, the elements are grouped into four classes according to Bohr. They are Inert gases. Representative or Normal elements; Transition elements; Inner transition elements and are called Bohr'sclassification.

5) Atomic or ionic radius is a measure of the effective size of the atoms or ions. Atomic radius has different value in different environments.

6) Ionisation energy is the energy required to remove the most loosely bound electron (i.e. the outer most electron) from an isolated gaseous atom of an element in its lower energy state (i.e. ground state) to produce a cation.

7) Electronegativity in the measure of the ability of bonded atom to attract the shared electron pair towards itself.

8) Electronaffinity is the energy released when an electron is added to an isolated neutral gaseous atom in lowest energy state (i.e ground state) to produce an anion.

9) In a group, atomic size increases and consequently ionisation energy, electron affinity and electronegativity increases.

Teaching aid: A "periodic table" chart is classically invougued for this purpose. So it is desirable to have the periodic table, quite informative one. The classical periodic table bears the following informations, such as symbol of the elements, atomic numbers, and atomic weights.

In addition to these, the Table should be provided with electronic configurations, percentage abundances of the elements. However, for the discussion of the variation of different periodic properties of the elements (such as atomic and ionic size, ionisation potential, electronaffinity and electronegativity etc.). The use of separate periodic table for each of the properties would be more appropriate. In such periodic charts, gradation of properties are represented pictorially as the gradation of the size of the circles The circle represents the value of a particular property of the elements in that periodic chart. The value of the property is also given along with the circle. (as in Table -1 and Table-2)*

Such"periodic table" charts can be made enlarged and other similar charts on different properties can be prepared indigenously. The chart may be made attrac-ti using different colours. For examples, metals and non-metals can be shown distinctly using different colours.

The demonstration of such periodic tables would certainly be more helpful and valuable teaching aid for a better understanding of the topic.

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*(Table-1 and Table-2 are already distributed among the participants).

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TEACHING OF WAVES

Dr.B.K.Parida,
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Till the early part of the present century it was thought that our Universe consisted of 'particles' and 'waves'. Then it was discovered that at the microscopic level particles behavelike waves and waves behave like particles. The importance of wave phenomena can, therefore, never be over-emphasized. Like many other topics in Science, teaching/learning of 'waves' is not easy and involves both physical observations and mental exercises. To facilitate teaching/learning of waves at the school level we suggest below some strategies/activities and aids which may be adopted by the concerned teachers.

Strategies

(i) The teacher may ask his students if they know what a wave is.

(ii) The students may be asked to give as many examples of waves as they can. These may be put in different groups by the teacher.

(iii) They may be asked to recollect their experiences with waves and state their observations in some detail, for example, in case of waves on water. This may indicate and excite their keenness of observation.

(iv) The students may be asked if they find anything common between the various types of waves they have experienced. These characteristics may be noted down by the teacher and used to develop the lesson.

The above will give a "child centred" orientation" to the subject, which has been recognised as an important aspect of teaching. Moreover, these will help bring out the alternative conceptions of the children about waves which can then be suitably taken care of by the teacher for more effective teaching.

(v) Actual demonstration of a wave phenomenon as, for example, waves on a string or on water surface would be very helpful. The teacher may try various strings, springs, tubes etc. and find one which gives an observable wave phenomenon. Some books like the PSSC book on Physics contain excellent photographs illustratin various aspects of waves. They may be used profitably. The students need be asked to take active part in demonstration of wave phenomena. If needed, the teacher may announce that his pupils are working and observing like Scientists. This would motivate them to learn more and more about waves and enhance their interest in other topics/subjects as well.

(vi) After discussing general characteristics of waves, different classifications of waves may be discussed to illustrate the various aspects of wave phenomena.

(vii) Graphical method of dealing with waves is convenient for visualization and may be adopted. The students should be trained to draw various wave forms.

Points to be emphasized:

In course of teaching waves the following points may be emphasized to avoid confusion and for better understanding.

(i) In a wave phenomenon, the wave form or shape of the disturbance moves from place to place at a definite speed which can be calculated.

(ii) Vibrations create waves. This can, for example, be demonstrated by inserting a stick in a trough of water and moving it back and forth.

(iii) Wave is a mechanism which carries energy from one point to another.

(iv) Whereas energy itself is invisible, some types of waves are visible (e.g. waves on a string, waves on water surface, waves on a fluttering flag, waves on a waving hand kerchief) . There are also other invisible types of waves, e.g. light, sound, radio waves etc.

(v) Importance of waves: Without waves we cannot survive since most of the solar energy reaches us as waves. Without waves communication between persons and places would not be possible. In medical science, information regarding body parts like heart , brain is obtained in the form of waves in ECG and EEG.

(vi) In the study of wave phenomena some idealizations and approximations are used. When a pulse is propagating along a string it gradually diminishes because of the resistance offered by the medium like air and due to the internal resistance of the string. This is a complicated situation. Another complication is known to occur when wave amplitudes are large. To avoid these complications of a real life situation, we usually idealize the medium and the string to be resistance free and keep the amplitudes reasonably small. Construction and use of mental pictures is a great help in this regard.

A zero cost teaching aid

A no cost teaching aid is suggested below to illustrate some aspects of wave phenomenon. The teacher may modify/improve this design or devise new aids for the purpose of teaching waves.

A narrow, long strip of paper is uniformly folded up. When opened it may look like Fig.1 which may be considered to be a snap shot of a wave.

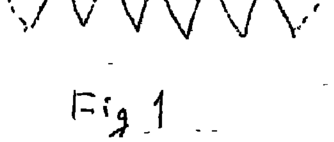
Fig 1

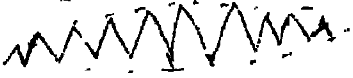
Fig 2

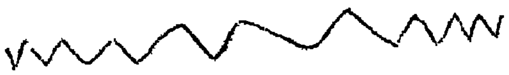
Fig 3

This can be used to illustrate important concepts like amplitude, wave length, phase, wave front etc. In fact, amplitude and wavelength can be directly measured with a scale.

Another narrow, long strip of paper is folded unevenly such that on opening up it looks like Fig.2. This can be easily used to demonstrate the ideas of amplitude modulation (Fig.2) and frequency modulation (Fig.3) which are so vital in, e.g. radio and micro-wave communications.

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ELECTROVALENT BOND

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Introduction

Teaching is a complex process comprising of identification of instructional objectives, selection and sequencing of learning experiences to develop various concepts concerning the lesson. Effectiveness of the teaching much depends upon how effectively each of these component acts are caried out. The various activities performd by a teacher in the class room are intended to result in learning inthe children. Three levels of learning can be listed: i) cognitive domain which is related with recall/recognition of knowledge and the development of intellectual skills and abilitis of application of knowledge. Learning is a process by which the pupils acquire new forms of behaviour. This change in behaviour can be stated in terms of its outward manifestation and are stated as specific objectives of a lesson in the form of what pupil does if he understands and how to ensure that he has understood. These are also termed as behavioural outcomes and can be listed under three levels:

a) Knowledge- recall, recognition of terms, processes, definitions, formulae and so on.

b) Understanding- give example, discriminate between, see relationship between, verify, interpret, classify, generalize and so on.

c) Application-formulate and establish hypothesis, reason out, infer, predict and so on.

The following is an illustration of a lesson on 'Electrovalent Bond' which comprises instructional goals and their specification in terms of pupil behaviour, concepts, teaching points and sequential learning experiences with appropriate expected learning outcomes

The Lesson

Instructional goals of the lesson are: to enabl the pupils to,

i) acquire the knowledge of the terms electrovalent bond and electrovalent compound,

ii) understand the formation of electrovalent bond, and

iii) apply the knowledge and understanding gained in new situations.

Concepts - 1. Atoms combine to acquire stable electron configuration.

2. Atoms of some elements attain stable electron configuration by loss of electr and atoms of some elements attain stability by the gain of electrons.

3. An atom by the loss of an electron becom a positively charged ion and an atom by the gain of electron become negatively charged.

4. An electrovalent bond is formed when an valence is transferred from an atom with greater tendency to lose electrons to an atom with greater affinity for electrons.

Sequential Learning Experiences	Expected Behavioural Outcome
1. Teacher takes a trough of water and drops a piece of sodium metal into it and asks the pupils to observe.	Recognise: sodium reacts vigorously with water liberating a gas.
2. Teacher drops a pinch of salt (sodium chloride) into another trough of water and the pupil observe again.	Recognise: Sodium chloride does not react vigorously.
3. Teacher asks: i) "What is present in sodium metal?	Recall: atoms of sodium
4. ii) If the molecular formula of sodium chloride is NaCl, what are the atoms with which it is made up of ?	Recognise: sodium and chlorine
5. iii) Why is sodium in NaCl not reactive whereas sodium atoms in the metal are reactive ? Let us try out an answer for this.	Recall: names of some inert gases to find.
6. Teacher asks the pupils to name some inert gases and compared their electron configuration.	Recognise: inert gases have eight electrons in the outermost shell.
7. Teacher explains that the inert nature of these gases is due to the presence of an actet of electrons in the outermost shell and this is a stable electron configuration.	
8. Teacher shows a periodic table of elements and asks the pupils to identify the inert gas which is nearer to Na in it.	Recognise: neon

9. Teacher asks, i) "What is the electron configuration of neon?	Recall: 2,8
10.ii) What is the electron configuration of sodium?"	Recall: 2,8.1
11.Teacher asks the pupils to compare the two and think how sodium atom attains stability.	Recognise: Na has one electron more than what Ne has
12.Then he asks, i) "What are the ways by which sodium can get an octet of electrons?	See relationship: i) acquiring an octet of electrons in the outermost shell by the gain of 7 electrons or by the loss of an electron.
13.ii) Which process is easier out of the two?	Reason out: loss of an electron is easier.
14.Teacher explains that sodium has a total of 11 electrons and an equal number of protons. Since electrons are negatively charged and protons are positively charged there is a total of 11 positive and an equal 11 negative charges. That is why sodium atoms have no net charge on them. But when sodium loses an electron from the outermost shell to attain stability what happens to the charge of the residual atom.	Recognise: sodium atom becomes positively charged sodium ion (Na)
15.Now let us have a look at the electron configuration of chlorine. If chlorine has the atomic no.17, what is its electron configuration and how many electrons are present in its outermost shell?	Recognise: 2, 8.7 7 electrons in the outermost shell.

16. Then he asks, i) What are the ways by which chlorine can get an octet of electrons?	See relationship: i) acquiring an octet of electrons in the outermost shell by the gain of 1 electron or by the loss of 7 electrons.
17. ii) Which process is easier out of the two?	Reason out: gain of an electron is easier.
18. What would happen to the charge of chlorine atom after gaining of an electron? Name the inert gas whose electron configuration resembles that of Cl. so, sodium atom has a tendency to lose an electron and chlorine atom has a tendency to gain an electron. Let us see what happens when sodium is allowed to react with chlorine. Teacher introduces hot sodium in a gas jar of chlorine and ask the pupils to observe.	Recognise: chlorine atom becomes chloride ion (Cl) Recognise: Argon Recognise: sodium burns in the presence of chlorine producing white fumes.
19. What could be these fumes ?	Hypothesise: sodium chloride formation
20. In the formation of sodium chloride what could have happened to sodium and chlorine atoms?	Hypothesise: might have got converted into ions; sodium losing an electron to become Na ion and chlorine gaining an electron to become Cl ion
21. Where from the chlorine atome gets an electron?	Hypothesise: from sodium atom.
22. It means, when sodium reacts with chlorine, there is transfer of electron from sodium atom to chlorine atom. As a result sodium atom gets converted into sodium ion and chlorine	Recall: attractive force

atom gets converted into chloride ion. Since those two ions are oppositely charged what type of force exist between them? These forces are called electrostatic forces. These hold the two oppositely charged ions together in the molecule of a compound and form an electrovalent bond and the compound in which such bonds exist are called electrovalent compounds.	
23. Why is sodium in sodium chloride not reactive?	Reason out: because sodium has attained stability through an octet of electro
24. Teacher performs another experiment: Burns a piece of magnesium ribbon and tells the pupils that in this process magnesium combines with oxygen of the air to form white powder which is magnesium oxide (MgO). Teacher gives pupils an exercise to work out the formation of MgO.	
25. From these examples when do you expect an electrovalent bond to be formed?	Hypothesise: electrovalent bond is formed when an ato with a greater tendency to lose an electron reacts wi an atom with greater affinity for electrons.
26. Teacher performs another experiment to show that sodium chloride solution conducts electricity [illegible]	Hypothesise: Due to Na and Cl ions and carbon tetrachloride may not have ions

whereas carbon tetrachloride does not and **asks** the pupils to explain this fact.

[illegible]
[illegible] chloride

27. If so how carbon tetrachloride is formed/let us try to answer this in the next class.

Assignment:

1. Find out from the periodic table of elements, the groups to which atoms of various elements that form electrovalent bond belong.
2. Give some examples of electrovalent compounds which you come across in daily life and explain their formation.

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STRUCTURE OF ATOM

Dr.H.H.Tripathy,
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Introduction

Chemistry is a branch of science which deals with varieties of matter. Dalton's Atomic Theory was the first and very important theory, which looked as if the last word on structure of matter. According to this theory, atoms of one kind behave differently when compared to the others and hence account for the difference in their respective properties. For exampl sodium is kept in kerosene and in fact cannot be kept in water whereas phosphorous is preserved under water. The difference in the colour of the glow of neon signs and fluoroscent tubes is another example. Why do atoms of different kind behave differently? The answer to this question comes from the study of structure of atom.

Some significant discoveries inphysical sciences were made towards the end of the last century. These were the study of the phenomena of i) discharge of electricity through gases, ii) scattering of alpha particles by metal foils, iii) radiation emitted by atoms, iv) wave-particle dualism, and v) uncertainity principle. These milestones in experiment and theory give us the structure of atom as we understand it today. Now we list the objectives of teaching structure of atom at secondary level.

Objectives

Pupils are expected to be able to:

1. List fundamental particles present in an atom,
2. Differentiate between these particles,
3. Describe various models of atom and discuss their respective validity in relation to the experimental observations,

4. interprete spectra in terms of transfer of electron from one energy state to another,
5. define Heisenberg's uncertainity principle,
6. explain the introduction of four quantum numbers to define the energy state of an electron in an atom, and
7. draw schematic diagram for the filling up of electrons as per their energy levels.

Fulfilment of thse objectives needs a good comprehension of the related concepts which may be shortlisted as follows.

Concepts

1. Atoms (and hence the matter) are electrical in nature.
2. Like matter electricity is also particulate in nature, that is electric discharge takes place in discrete units.
3. Atom is composed of electrons, protons and neutrons.
4. Arrangement of electrons, protons and neutrons in an atoms is explained by a number of models such as Thomson and Rutherford models.Out of these the latter model is currently accepted as most satisfying on the basis of the experimental data. According to this model protons and neutrons are situated in a very small volume compared to the size of the atom and costitute so called the nucleus of the atom, and electrons are in motion around the nucleus and fill most of the space of the atom.
5. Radiant energy 'E' is emitted or absorbed, not continuously but in discrete units called quanta defined by $E=h\nu$ where 'h' is the famous Planck's constant and ν is the frequency of the radiation.
6. The radiant energy in the form of spectral lines is emitted as a consequence of transference of electrons from higher energy level to lower energy level.

7. Electrons (as well as matter) exhibit both wave a particle nature symbolised by the de Broglie relationship $\lambda = h/p$ where 'h' is again the Planck' constant, 'p' is the momentum of the particle, an 'λ' is the wavelength of the wave associated wi the particle.
8. It is impossible to simultaneously (at the same time) determine both the position and momentum of an electron exactly or with equal degree of accu
9. The region around the nucleus, where there is maximum probability of finding the electron is called an orbital and the wave function of an el tron defines an orbital.
10. An electron in an atom may be completely described by a set of four quantum numbers.
11. No two electrons in an atom have the same set of all the four quantum numbers (Pauli Exclusion Principle).
12. Electrons are filled in various orbitals in orde of increasing energy.

The Strategy

Development of the above listed concepts by th teacher in the classroom situation is no doubt a difficult task as it is difficult to pick up example for this topic from the environment or from the real life. However there are some activities which can be carried out in the class with simple items/apparatus so as to create sufficient motivation among the pupi so that they develop certain concepts on atom which Mahatma Gandhi compared with 'Atma'. One thing is certain in this regard that the teacher should have sufficient mastery over this content. Then only he c venture to explain these concepts to pupils and achi the listed objectives. For this a plan consisting of the following sequential steps is suggested.

STEP I: Recall and test the previous knowledge prerequisite for the new topic. This forms the foundation of the strategy.

STEP II: Introduce the topic, as intimately as possible stressing its importance in respect of its application in daily life; inviting the experience of the pupils and thus taking into account their alternative concepts.

STEP III: Develop the concepts inthe sequence listed earlier using as far as possible the following approaches, methods and skills.

Approach - Learner - centered and Logical; Methods-Inductive-deductive and Lecture-cum-demonstration; Skills-Listing of relevant examples and generating curiosity. A judicious cobination of approach method and skills defines a particular strategy of teaching this topic.

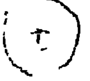
STEP IV: For a given lesson and also at the end of the teaching of this topic all the concepts should be summarised by asking questions to the pupils.

STEP V: Suitable home assignment should be given to the students to practise the acquired knowledge and to further enrich it.

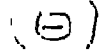
A brief exemplar for the Step III is suggested as follows:

A balloon filled with air when rubbed slowly and carefully on a synthetic fibre-shirt and then brought near the wall; will be attracted by the wall. Two such balloons when suspended with the help of a thread can be seen to repel each other slightly. It is also observed that while taking out a terylene or polyester shirt from the body the hair of the body point away from the body and if we are careful we can hear or inthe darkness can even see the sparks passing between the hair and the shirt. The plastic comb or for that matter any plastic object when rubbed by another surface, attracts small bits of paper. When we comb our dry hair by a comb they stand apart due to mutual repulsion. If we take d mustard seeds on a plastic plate and just rub them gent onthe plate we can see them move violently away from each other. Such observations show that matter is electrical in nature. While citing such examples we should see that some of them come from the pupils as well. Also if we stick to prototype examples of glass and ebonite rods and catskin and silk pupils may develop a wrong concept that only these substances have electrical nature.

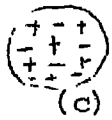
On the basis of above examples and citing the study of the electric discharge through gases we shoul try to convince the pupils logically about the electrical nature of matter and also of the fact that atom is electrically neutral but contains very light negatively charged particles called electrons. Further it can be said that following three models could be thought of to describe the atom.



(a)
positive charge
at the centre



(b)
negative charge
at the centre



(c)
uniform distributi
of +ve and -ve char

At this stage, Rutherford's observations on scattering of alpha particles may be recalled as follows;

i) most of the positively charged alpha particles pass through the thin gold foil undeflected, ii) some of the are deflected at large angles, and iii) a very few of them rebound back along their initial path at 180 degre Now discussions can be held on each of the three models This discussion would lead logically to the following conclusions.

1) Since most of the alpha particles pass throug the foil undeflected, it looks as if the atom is mostly empty space.

2) Since a very few alpha particles are scattered through very large angles the positively charged part of the atom should occupy a very small volume of the entire atom.

3) A deflection through 180 degrees indicates that there is an intense electric field inside the atom. Since a positive charge spread over the whole of atom will be incapable of producing such a field so it is concluded that the positive charge is concentrated in a very small volume at the centre of the atom. This central positively charged massive body of the atom is known as its nucleus and electrons revolve around the nucleus in empty space.

Similar exemplars to develop other concepts may be thought of and evolved which in most of the cases be based on logical approach and can be made more helpful for transacting the curriculum in a more meaningful manner to the child.

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ATOMIC WEIGHTS, MOLECULAR WEIGHTS AND CONCEPT OF A MOLE

Dr. S. K. Mohapatra,
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CONCEPTS

1. Atomic masses and molecular masses are numbers expressing relative heaviness of atoms and molecules with respect to that of a hydrogen atom (subsequentl changed to 1/12th of a carbon atom).
2. Mole is a chemical unit.
   - (a) It represents a large number (6.02×10^{23}) of atom or molecules of the substance.
   - (b) The mass of a 'mole' of any substance is equal to its atomic mass or molecular mass expressed in grams.
   - (c) A mole of any substance will occupy a volume of 22.414 liters at STP if it can exist as a gas at STP.
3. A balanced chemical equation represents mole relationship of reactants and products.
4. Molecular formula also represents the mole ratio of the elements present in the substance.

DEVELOPMENT

1. Mass is the material content while weight is the force with which it is attracted towards the center of the earth. But both the terms have bee used interchangeably and convey the same meaning though strictly speaking they are not same.
2. Our most frequent encounter with atoms or molecules is in handling a very large numbers of the in various substances, we use everyday whose mass we can determine but not the number. For example we can weigh a small strip of magnesium ribbon quite accurately but we have no way to count the number of atoms in the strip.

3. We can find the mass or weight of a rice grain or a mustard seed as we can see them. Counting is also possible. Weighing a single grain or a seed might be difficult but weighing 10 or 20 of them together is possible and then we can find the mass of each grain (of course assuming all the grains to have identical mass - Dalton suggested all atoms and molecules of any substance have identical mass).

4. When we do not have any standard weights as 1gr. 500 mg, 200 mg weight with us, we still can compare the mass of a rice grain with that of a mustard seed. We will find out how many grains of rice exactly balance 10 or 20 mustard seeds i.e. we can talk of relative heaviness as one grain of rice is twice/thrice as heavy as one grain of mustard seed.

5. So also, when we are dealing with very very small particles which we can not see with our naked eye, and counting is unimaginable we can still think of their relative mass and relative heaviness.

6. Therefore, Atomic wt or molecular weight was defined as how many times an atom or a molecule is heavier than one atom of hydrogen the lightest element known to us i.e.

$$\text{atomic weight or mass} = \frac{\text{wt of one atom of the element}}{\text{wt of one atom of the hydrogen}}$$

$$\text{Molecular weight} = \frac{\text{wt of one molecule of substance}}{\text{wt of one atom of hydrogen}}$$

Assuming equal volumes of all gases under similar conditions of temperature and pressure contain equal number of molecules one can define,

$$\text{Relative density} = \frac{\text{wt of a certain volume of a gas}}{\text{wt of same volume of another gas}}$$

Experiments show:

One litre of hydrogen weigh	0.089	gm(*)
One litre of chlorine weigh	0.16	gm
One litre of oxygen weigh	1.428	gm
One litre of CO_2 weigh	1.968	gm

Note:Weight of a certain volume of hydrogen can not be determined by this method.

All measurements made at STP.

(Collect the data of your students and tell them about limitations and uncertainity in measurements for the deviations).

$$\text{Relative density} = \frac{\text{wt of one molecule of the gas}}{\text{wt of one molecule of hydrogen}}$$

Assuming hydrogen, oxygen and chlorine molecules to be diatomic

$$= 1/2 \times \frac{\text{wt of one molecule of the gas}}{\text{wt of one atom of hydrogen}}$$

$$= 1/2 \times \text{molecular weight}$$

$$\text{or Molecular weight} = 2 \times \text{RD}$$

Thus RD for $O_2 = \frac{1.428}{.089} = 16$. i.e. relative heaviness=1 and molecular weight = 3

For $Cl_2 = \frac{3.16}{.089} = 35.5$ and molecular

Weight = 32 and molecular weight = 71

$$\text{In case of elements R.D.} = \frac{\text{wt of one atom of the elemen}}{\text{wt of one atom of Hydrogen}}$$

$$= \text{atomic wt.}$$

Let us go back and have a look at our data. Following the arguments given above we can say

$$\frac{\text{Weight of one molecule of } CO_2}{\text{Weight of one molecule of } CO_2} = \frac{W_4}{W_3}$$

This gives the relative heaviness of carbondioxide with respect to oxygen.

We can also state

$$\frac{\text{Wt. of one molecule of } CO_2/\text{Wt of one atom of hydrogen}}{\text{Wt. of one molecule of } O_2/\text{Wt of one atom of hydrogen}} = \frac{W_4}{W_3}.$$

a $$\frac{\text{Molecular weight of } CO_2}{\text{Molecular weight of } O_2} = \frac{W_4}{W_3}$$

Now if we take the molecular weight of oxygen to be 32, the molecular weight of $CO_2 = 32 X \frac{W_4}{3} = 44$

4. CONCEPT OF MOLE:

The relative atomic or molecular mass so determined do not tell us how many atoms or molecules are present in one gram of hydrogen or 16 grams of oxygen i.e. atomic wts, and molecular wts do not tell us the exact mass of an atom or a molecule. It only tells us about their relative mass.

Chemistry is a quantitative science and chemist is interested to know the number of atoms or molecules or ions in given weights of the substances which combine so that he can know how many atoms or molecules of one combines with how many atoms or molecules of another this is necessary in order to arrive at the molecular formula or give the balanced equation. Such equations enable him to find out one gram of an element, A will combine with how many grams of B and how many grams of AB will be formed or if he takes 10 grams of carbon and 10 grams of O_2 and allow them to react how many grams of carbon dioxide will be formed and how many grams of carbon or oxygen will be left behind unreacted.

15. This necessitated to use a unit which is based on measurement of masses of a fixed number of atoms or molecules or ions of any substance i.e. a unit for expressing the masses of a fixed number of atoms or molecules. This chemical unit is known as a mole - like a dozen of banana or a gross of test-tubes.

In the beginning it was agreed upon that the number of molecules present in 32 grams of oxygen has that fixed number of molecules. They did not know how big or small is that number. Later on found it was found to be 6.02×10^{23} and called Avogadro's number.

16. Since one litere of hydrogen weighs .089 gm and one litre of oxygen weighs 1.428 grams and aqual volume of all gases have the same number of molecules, 0.089 gms of hydrogen has the same number of molecules as 1.428 grams of oxygen or 2 grams of hydrogen has the same number of molecules

$\frac{(1.428 \times 2)}{.089}$ = 32 grams of oxygen (i.e. 6.02×10^{2} molecules). In otherwords molecular wts of differen substances expressed in grams represent one mole of them. Since atomic wts and molecular wts are related to each other by simple multiples in case of elements (excepting the rare gases) atomic wts expressed in grams represent 1 mole of atoms of the substance i.e. 6.02×10^{23} atoms of the substance. For example molecular wt. of O_2 = 32 80.32 grams of oxygen stands for 6.02×10^{23} molecules or $2 \times 6.02 \times 10^{23}$ atoms. Therefore the weight of 6.02×10^{23} atoms oxygen would be 16 gram or one mole of oxygen atoms = 16 grams i.e. its atomic wt. expressed in grams.

$$\text{Therefore mass of a molecule of a substance} = \frac{\text{Molecular wt of the substance in grams}}{6.02 \times 10^{23}}$$

$$\text{Mass of an atom of an element} = \frac{\text{atomic wt of the element in}}{6.02 \times 10^{23}}$$

$$\text{Atomic mass of hydrogen} = \frac{1 \text{ grams}}{6.02 \times 10^{23}} = 1.66 \times 10^{-24}$$

$$= 1 \text{ atomic mass unit (a.m.u.)}$$

$$\text{Number of moles in a given wt of any substance} = \frac{\text{Weight of the substance in}}{\text{molecular wt in gm}}$$

$$= \frac{W}{M}$$

17. Again one litre of hydrogen weighs 0.089 gms therefore 2 grams of H_2 will occupy a volume 2/0.89 = 22.4 litres, so also 32 grams of O_2 44 gms of CO

will occupy 22.4 litres at 0°C and one atmospheric pressure. Therefore, of one mole of any gas occupies 22.4 litres at STP. This volume is called molar volume. Therefore if w know the volume of any gas at STP or at any other temp. and pressure we can calculate the number of moles of the gas present and hence the number of molecules present and the mass of that volume of gas.

22.4 litres ← occupies — One mole of any substance — contains → $6.02\text{x}10^{23}$ atoms, molecules or ions

↓

Weighs
atomic or molecular weight
expressed in grams.

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CARBON AND ITS COMPOUNDS

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Many organic compounds like alcohol, sugar, fat, soap and vinegar, indigo, starch were known to prehistoric people. In 18th Century organic compounds were established from natural sources.

Scientist Scheela obtained tartaric acid, Citri acid from grapes and apples. Lactic acid was obtained from sour milk. Some other scientists also produced oxalic acid by oxidation of sugar with HNo_3 and glycer from animal fats. Urea was obtained from urine and alkaloid morphic from opium.

Benzelus was the scientist who named these substances derived from living organisms as organic compounds or compounds of carbon. It was thought of a that time that organic compounds cannot be synthesised in the laboratory from inanimate things. Some vital force is required to obtain these from living sources.

Wohles accidentally obtained urea from boilin of solution of Ammonium cyanate which is a typical inorganic compound.

$$NH_4CNO \xrightarrow{H_2O} NH_2 - \overset{O}{\overset{\|}{0}} - NH_2 \quad \text{Urea}$$

After this a number of compounds could be synthesised in the laboratory from different elements.

Carbon and its compounds occupy a special position in Chemistry due to the following points.

(1) Carbon and its compounds form a large number of compounds around 4 million compared to 50,000 is inorganic compounds.

(2) They are built of relatively few elements C, H, O, N, S, P and halogens.

(3) They are classified according to the functional grs. Functional grs. are groups of atoms which are active and its chemical behaviour is

determined by it. That -OH, -CHO, -WoH, - NH_2 which are known as hydroxyl, aldehyde, carbonyl and amino grs.

(4) These compounds form covalent bonds. They are generally coloured compounds. This reactions are slow. They have low b.p. and m.p.

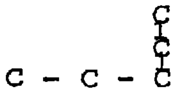
Carbon belongs to Gr-IV of the periodic table, other members being Silcon, Germanium, Tin and Lead. It has four electrons in the outer most shell.

In nature pure carbon occurs in two forms diamond and graphite. One is a bright shining crystal type other is a dark and dull type. But both when burnt produce equal quantity of CO_2 leaving no other residue. This shows they are identical and consist of only carbon atoms. That means both diamond and graphite are same in their chemical properties but they differ in physical properties. This property of carbon is called allotropy of carbon. In both the cases the arrangements of carbon atoms are different. In diamond the shape is tetrahedral. The atoms are tightly packed, covalently bonded.

It is one of the hardest substance known. M.P. of diamond is 3500°C . Light rays passing through it shapes bend. It has a high refraction order. Graphite on the other hand the carbon atoms are arranged in a layer form of hexagonal networks. The atoms are not tightly packed. They are separated by large distance. The 4th valence electron here is free. The layers slide over one another. Graphite is good conductor of electricity. It is a soft and grey in appearance. The M.P. of graphite is very high but it is very soft. The most interesting thing is when graphite is heated under high pressure in presence of catalysts changes to diamond. So from a dull substance we can get a shining bright substance.

(5) The most important property of carbon is that it undergoes 'Catenation'. This is why carbon is unique among the elements. Its atoms possess the wonderful capacity to unite with each other by means

of stable covalent bonds. Carbon atoms join each to each in straight chains, branched chains or rings of one sizes form a large number of simple as well as complex molecules. This self linking property of carbon is known as Cateralion. This property is responsible for the formation of such a large variety and large number of organic compounds.



$\mathrm{C - C - }\begin{array}[b]{c}\mathrm{C}\\|\\\mathrm{C}\\|\\\mathrm{C}\end{array}$ $\mathrm{C - C - C - C}$

(6) These compounds exhibit Isomerism . They give rise to a variety of spatial arrangements of atoms is organic molecules.

(7) The majority of organic compounds are insoluble in water but they readily dissolve in non-polar solvents like benzene chloroform, and ether. However the organic compounds containing polar yrs.

e.g. - OH, -COOH, - SO_3H are soluble in water. The inorganic compounds on the contrary are readily soluble in water and insoluble in organic solvents.

(8) Organic compounds are non-conductor of electricity.

(9) Organic compounds are volatile and possess low M.P. and B.P.

(10) Organic compounds are combustible. They readily burn in stream of oxygen, leaving no residue. In contrast inorganic compounds are generally incombustible.

(11) Organic reactions being moleculars are slow and reversible. They often require heat and a catalyst for good yield.

Sources of Organic Compounds

Organic compounds as mentioned are obtained from natural sources and are also prepared by synthesis in the laboratory. The natural sources of these substances are either from plant or animal kingdom.

Plants:- Sugars, Starches, Cellulose, Citric acid, Oxalis acid, Tartarik acid, indigo, oils, Vitamins etc.

Animals:-Fats, Proteins, Urea, Uric acid, Vitamins, Harmones etc.

Wood distillation:- Acetin acid, methyl, alcohol and acetone.

Coal-tar distillation:- Benzene, toluese napthalene, carbolic acid, Cresols, Pyridine, Dyes, perfumes drugs etc.

Natural gas and Petroleum distillation:- Alkanes and their derivatives such as methyl chloride, Chloroform, methyl alcohol, Ethyl alcohol, chloride, benzene, toluene.

Fermentation Process:- Ethyl alcohol, acryl alcohol, acetic acid etc.

About 40 years back the main sources of organic compounds were the processes of fermentation and wood distillation, where fewer compounds were derived from coal and petroleum. With the recent development of petrochemical industry and low temperature cokes techniques of coal, the number of organic compounds derived from petroleum and coal is far greater than from any other natural sources.

Although the fermentation processes are still in use, wood distillation is not of use. Vast majority of organic compounds are obtained by synthetic methods.

Organic compounds are devided into two main branches Acyctin or open chain and cyctin or Cyclic or ring srj. are organic divided into carbocyclic and heterocyclic . Carbocyclic compounds are again divided into Alicyclic and Aromatic.

Carbon combines with hydrogen to form a number of compounds known as Hydrocarbons. Hydrocarbons are classified into three types. Alkanes, Alkenes and Alkynes. Alkanes have a general formula C_nH_{2n+2} and Alkenes C_nH_{2n} and Alkynes C_nH_{2n-2}. This preparation and chemical properties are different. Alkanes being saturated compounds are not so active and they react only under drastic condition. Alkanes and Alkynes are unsaturated compounds so they give a number of additional products. In the case of Alkynes the addition takes place twice as they are triple bonded molecules.

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TEACHING OF CIRCULAR MOTION

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In nature bodies exhibit a remarkable tendency to travel in circular/curved paths. Planets revolve around the Sun, moon revolves around the earth in nearly circular orbits, and the electron revolves around the nucleus in atomic dimensions. Thus the concept of circular motion is very important to understand certain basic laws of nature.

From our point of view we restrict ourselves to uniform circular motion i.e. the motion executed by a body travelling in a circular path or a circle at a constant speed. In such type of motion though the speed of the body has the same numerical value all the time, the direction of the body's motion changes constantly. A body executing circular motion is acted upon by an inward force called "Centripetal Force", literally which means "Force moving towards the center". When a body executing circular motion is released from the effect of centripetal force. It will fly off tangent to its original circular path. The centripetal force $'F'_c$ which act on a body executing circular motion is expressed as

$$F_c = \frac{m v^2}{r}$$

Where,

m = Mass of the body.

v = Constant speed with which the body is moving

r = Radius of the circular path.

To introduce the above concepts to the secondary school pupils let us take a mass i.e. small piece of stone or a hard rubber ball of small size and attach it to a string and whirl the mass by holding the other end of the string. Whirl it for some time so that the mass attains a constant speed. If the string is released the stone flies off tangent to its original circular path. This simple arrangement can be taken to the play ground to have the following experiments and observations.

Activity No.1:

To know approximately the speed '$\vec{v}$' of the mass attached to the string executing uniform circular motion.

- Measure the length (l) of the string by using a scale.
- Whirled the mass and when the stone attains constant speed start counting by using a watch, how many times you are rotating your hand per minute. Divide the number of rotation per minute by 60 to get the number of rotations per second, to get say 'n' .
- Distance covered by the stone per revolution $= 2\pi \times$ length of the string $= 2\pi l$. Hence distance travelled per second $= 2\pi l n$ i.e length of the loop x Number of revolutions per sec.
- Speed of the stone

$$= \frac{\text{Distance travelled}}{\text{Time}}$$

$$= \frac{2\pi l n}{\text{'1' second}} = 2\pi l n \text{ CM/Sec.}$$

Here it is assumed that the stone is executing uniform circular motion under a constant centripetal force.

Activity No.2:

To draw a graph between the number of revolutions per second 'n' and the distance travelled by the stone when it is released.

- Whril the stone and count the number of revolution per second i.e. 'F'.
- Release the string from hand, the stone will fly tangential to the circular path and measure the horizontal distance (d) the stone will travel i.e the distance between the foot of the person performing the experiment and the point where it will touch the ground.
- Go on increasing the number of revolutions per second and measure the corresponding distance (d) after releasing it. Draw the graph between 'F' and 'd' .

Activity No.3:

To calculate the centripetal acceleration ' a_c' by using the formula

$$a_c = \frac{v^2}{r}$$

where, = Velocity of the mass

$r = l$ = length of the string

Find out v as described under activity No.1 and l is the length of the string which is also known by measuring it with the help of a scale. Hence among using the formula a_c can be calculated.

Activity No.4:

To calculate the centripetal force by using the formula

$$F_c = ma_c = \frac{mv^2}{r}$$

Where m = Mass of the stone or the ball.

- Approximate mass of the stone can be determined by using a spring balance (or) by using a beam balance available in grocery shope.
- $\frac{v^2}{r} = a_c$ can be found out by using activity No.3.
- Take the product of m & a_c to find F_c.

The activities described above give the necessary concepts of circular motion by using the available materials in a rural life situation.

EXEMPLAR NO.1

Name of the Topic - Composition of Air
Level - Class X
Drafted by - Group Coordinators: Dr.Sura Prasad P and Shri Madhusudan Mohanty, and Group members: Shri Udaynath Sahu, Shri Binod Chandra Patnaik, and Sri Purna Chandra Rath.

Introduction

Air exists all around us. It is essential for all living things for the process of respiration. It also helps to bring about the climatic changes on eart It not only helps burning but also controls it because of the presence of nitrogen. The blanket of air around the earth also protects its inhabitants from high intensity ultra-violet radiation, provides the winged creatures on earth a medium to migrate from one place t another, and supports the modern day air travel. Teaching of any topic related to air presents us with a wide range of teaching skills. We are illustrating thi for the concepts related to the topic 'Composition of Air'.

Concepts

1. Air is present everywhere.
2. Air is in the gaseous state.
3. Air is a mixture of some known gases.
4. Air contains about 20% oxygen and 80% nitrogen.

Before we discuss the teaching strategy for these concepts, it is worth while to guess what can be the alternative concepts pupils may be carrying. We can think of the following:

i) Air exists only in inflated balloons and also there where we feel its motion.

ii) Air is same as oxygen.

Testing Previous Knowledge/Alternative Concepts:

Pupils may be allowed to sit in the room for some time without switching on the fan. They may be asked as to how they are feeling. They may feel hot or cold depending on the weather. Then the fan can be switched on and pupils asked to describe their feeling. They may say it is more pleasant or more cold depending on the climate of the day. If we ask them then what is the reason for this they are sure to say that the cause is the air that they feel blowing on their body. Similar activity can be arranged with the balloons. Pupils will find no difficulty in recognising that air fills the inflated balloon. But if we ask the same pupils to name the things in a room where there is no obvious air current, or for that matter the things inside a box or a bag, they will mention everything else but air. It would be interesting to study the reason for this. Two reasons come to our mind immediately. i) They do not consider the presence of air worth mentioning, or ii) Then Air exists only when it is blowing. The second alternative concept is about the composition of air and can be brought forth by following sequential questioning: i) which gas helps burning? Ans. - Oxygen. ii) Why does charcoal burn in air? Ans.-Air helps burning. What relation does oxygen have with air? Ans.-Air and oxygen are the same thing.

Presentation

We are giving this section in tabular form under the heads: Activity, Observation, and Inference followed by the relevant questions to be asked to the pupils along with expected answers.

Activity 1	Observation	Inference
Ask a pupil to immerse an empty bottle in a bucket filled with water.	Bubbles come out of the bottle and water gradually enters in the bottle.	There was something inside the bottle and it is displaced to accomodate water.

Follow up questions:

1. What is the state of the thing in the bottle ?
   Ans.- gaseous.
2. When we inhale what is the state of the substance we take in?
   Ans. - gaseous.
3. Do we inhale air at certain places only like home, ground or park or everywhere?
   Ans. - everywhere.
4. A polished iron nail is kept in open for some days, What change do you expect to find. the nail gets rusted.
5. How does the nail feel to our fingers (rough or smooth)?
   Ans.- rough
6. What is the colour of the rust?
   Ans.- brown.
7. What is the composition of rust ?
   Ans.- iron oxide.
8. Where does the oxygen come from ?
   Ans.- from air.

Activity 2	Observation	Inference
Take lime water in a beaker and allow it to stand for some time.	A thin layer of white material gets formed on the surface of lime water.	This is due to the presence of carbon-di-oxide.

Follow - up question:

1. Where does the carbon-di-oxide come from?
   And.-Air.

   We could not think for an activity for inferring the presence of nitrogen in air. Instead we sugg
   the following questions to be put to the pupils.

i) What is the important element found in proteins?
Ans.- Nitrogen.

ii) What type of salts does the plant need in its soil to produce the proteins?
Ans.-Nitrogeneous salts.

iii) How are these salts formed in the soil?
Ans.- Combination of nitrogen, oxygen and water present in air during the lightening discharge.

Activity 3	Observation	Inference
Take a glass and fill it with ice or cold water.	Small water droplets are formed on the outer surface of the glass.	This is due to the presence of water vapour present in the air.

Follow-up questions:

1. Name the sources from which water present in the air comes from .
Ans.-Evaporation of water from lakes, rivers, seas, wet clothes, body perspiration and steam from factories and engines.

2. Where from the dew-drops are formed in the morning specially in winter?
Ans.- from air.

3. What are the clouds made up of?
Ans.-Water vapour.

Activity 4	Observation	Inference
Close the doors and windows of a a room to make it dark. Make a small hole at a proper place to allow the direct sun rays into the room.	Small particles are found floating along the path of light.	Tiny dust particles are present in air.

Follow-up questions:

1. Give other observations indicating the presence of dust particles in air.

Activity 5	Observation	Inference
Take some water in a trough. Keep it on a table. Float a small plate fitted within a burning candle. Cover the candle with a graduated bell jar.	Gradually water rises in the bell jar. Candle burns more and more slowly. When the candle extinguishes water level stops rising.	As candle burns oxygen is spent produce carbon-oxide and water vapour which ge dissolved in th water and the water rises in the bell jar t fill up the partial vacuum created due to consumption of oxygen.

Follow-up questions:

1. What fraction of the total column of air earlier present in the bell jar, has the water level risen

   Ans.- approximately one fifth.

2. What can you say about the percentage of oxygen pre in the air?

   Ans.- approximately 20%.

Activities for Pupils:

1. Make a list of other gases likely to be present in air, taking into consideration burning of cow-dung and other fuels, emission from factories, volcanic erruption, decomposition of dead bodies, and so on.
2. Although air as well as water vapour are transparent and colourless, why does fog create poor visibility.

Note on related higher knowledge

1. Simpler activities may be thought of to establish the presence of nitrogen in air.
2. Convincing activities or reasoning may be provided in support of the percentage of different constituents of air especially nitrogen.

Conclusion

We have tried in this write-up ~~ep~~ to spell out in detail the activities, the follow-up questions, the developmental questions, which can help a teacher in teaching this unit on composition of air. We have also included some explorative and thought-provoking questions as assignment for the pupils. Lastly we have stated what higher knowledge teacher should have in relation to this unit.

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EXEMPLAR NO.2

Name of the Topic - Wave motion.

Level - Class IX

Drafted by - Group Coordinators:Dr.Sura Prasad Pati and Sri Madhusudan Mohanty, and Group members:
Shri Udaynath Sahu,
Shri Binod Chandra Patnaik,
and Shri Purna Chandra Rath

Introduction

The concept of wave is very fundamental to physics, the basic science of everything around us. We are all over surrounded by light waves coming from the sun in the day time and are also constantly bombarded by the radio and T.V. transmission waves which we neither see nor feel unless we switch on our T.V. or Radio sets to entertain ourselves with the audio-visual signals emitted by them which in turn are also longitudinal waves in air (audio), or light waves (visual) emitted from the T.V. screen. Teaching of such an important topic involves mostly environmental and logical approach and the skills of giving examples and asking questions. In what follows we are spelling out the details with reference to the following concepts

Concepts

1. Waves transmit energy.
2. Waves are of two types: Mechanical and Electro-magnetic.
3. Unlike Mechanical waves electromagnetic waves do not need material medium for their propogation.
4. In wave motion disturbance travels without the movement of the medium as a whole.

Testing Previous Knowledge/Alternative concepts

Pupils are aware of periodic changes occuring around them. These are: i) circular wavelike patterns produced on the surface of water when its calm is disturbed by dropping a small stone or by some other means, ii) Undulations of paddy crops in a gentle wind, iii) sea water washing the shore and receding alternately, iv) swinging of pendulum, iv) phases of moon, v) seasonal changes and so on. Pupils may think that all these are examples of waves. But they are not. So this aspect can be tested by asking suitable questions and then giving an explanation somewhat like this.

Although periodic changes with time at any place is the essential characteristic of a wave motion it is not sufficient. We call those phenomena under wave motion wherein periodic changes occur at different places in a medium or in space in a sequential manner without actual movement of the medium.

Presentation

We are giving this section in tabular form under the heads: Activity, Observation, and Inference followed by the relevant questions to be asked to the pupils along with expected answers.

Activity 1	Observation	Inference
Take a long and soft spring(s and fix it at one end stretch it on along a table or on floor, and give it a rapid jerk.	The pulse moves from one end to the other 2-3 times and finally dies.	The disturbance created at one point moved to other points on the spring.

Follow-up questions:

1. When the pulse moved from one point to the other did the material of the spring move from one point to the other?

   Ans.- No

2. Does the pulse have energy and of what type?

   Ans.- Yes, kinetic as well as potential.

Activity 2	Observation	Inference
Strike a tuning fork on rubber pad.	A sound is heard and vibrations of the fork can be felt on touching it.	Particles of the tuning fork vibrate when it makes sound.

Follow-up questions:

1. Is the wave generated on the tuning fork?
   Ans.-Yes.
2. Which part of the tuning fork vibrates most?
   Ans.-Tip.
3. When sound is created, what vibrates in air?
   Ans.- Air molecules.

Activity 3	Observation	Inference
Take a half filled tray or any utensil with broad mouth. Disturb its surface gently by adding a drop of water or any tiny thing to it.	A circular wave pattern made of elevation(crest) and depression (trough) can be seen.	Any disturbance i the medium at an place produces a pattern of disturbance at other places in the medium.

Follow-up questions:

1. Looking at the pattern produced onthe water surface of what can you say about the displacement of the water particles from their respective mean positions?
   Ans.- The displacement changes in a periodic fashion as one moves away from the centre of the patte
2. Looking at any one point on the pattern how does the displacement of water particles at that point change with time?
   Ans.- The displacement changes sinusoidally.
3. If we float some tiny piece of wood on the water surface carrying the pattern of waves, does the piece move in the direction of propagation of the wave? Ans.- No

4. What can you conclude from this observation that the floating wooden piece does not move in the direction of the propagation of the wave?
   Ans.- We can conclude that the medium does not move in the same manner as the disturbance moves from one place to another.

To impress upon the pupils the existence of some kind of waves all around us, their experience can be recalled with the help of the following questions:

1. When you watch the TV what do you enjoy?
   Ans.- Picture and sound.
2. What are the waves which create the sensation of light and sound in our brain?
   Ans.- Light and sound waves.

(if the pupils fail to give this response teacher can explain that the light waves are nothing but the undulations of electric and magnetic fields with the help of diagram and also that the sound waves are the to and fro vibrations of air particles again with diagrams of compressions and rarefactions; he should also impress upon them that both these waves are themselves invisible but are in no way different from the mechanical waves on the string as far as the characteristics of wave motion, namely, the periodicity in space, the periodicity in time and the movement of the disturbance is concerned.)

3. What does the antenna of the TV do?
   Ans.- Collect the electromagnetic waves incident on it in an efficient manner.
4. Wherefrom these waves come ?
   Ans.- From the nearby T.V. tower.
5. Where from does the TV transmitter goet the waves?
   Ans.- From the satellite.
6. What medium does exist between the satellite and the earth ?
   Ans.- No medium.

(Some pupils may respond that air exists between the satellite and the earth so they should be explained th the atmosphere of the earth extends only up to a few kilometers but the satellite is at a distance of 36000 kilometers away from the earth.)

7. What can you conclude from this observations that the electromagnetic waves from the satellite as well as light from sun reaches us?
   Ans. - Electromagnetic waves do not require any medium for their propagation.

Assignment for Pupils

1. On thedial of your radio/transistor set note down the numbers given as kHz or MHz and meters at the same setting of the tuning switch. Remember to read the appropriate line corresponding to the setting of the band switch (SW/MW). Multiply them together and see what do you get, Discuss with your friends and with your teacher.

2. Take a rectangular tray. Fill it with water to about one third of its capacity. Hold its longer side firmly and raise it a bit and then leave it. Observe the surface of water in the tray. You will see an elevation of water level moving back and forth on the surface. See whether water actually move with it by putting some tiny wooden pieces on the surface of water.

Note onRelated Higher Knowledge

The teacher should know the difference between a plane and spherical wave and also understand the reflection refraction and diffraction of waves because these phenomena are present in the environment of the pupils.

Conclusion

We have tried in this write-up to spell out in detail the activities, the follow-up questions, and the developmental questions, which can help a teacher in recalling the experiace of the pupils for teaching some concepts related to the unit on Wave Motion. We have also included some explorative and thought-provoking activities as assignment for the pupils. Lastly we have stated what higher knowledge teacher should have in relation to this unit.

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EXEMPLAR NO.3

Name of the Topic:- Other Sources of Energy

Level :- Class - X

Drafted by :- Group Coordinators: Dr.Sura Prasad Pati and Shri Madhusudan Mohanty, and Group members: Shri Udaynath Sa Shri Binod Chandra Patanaik, and Shri Purna Chandra Rath.

Introduction

Energy is one of the most important component of production and therefore influences our economy to a great extent. Rapid rise in population, industrialisation, adoption of modern farming techniques and increasing mechanisation demand enormous quantities of energy. Conventional energy sources such as fossil fuel reserves are fast diminishing because of their utilisation at a faster rate compared to pre-industria times. So it is essential to look for other sources of energy..These are called the nonconventional sources. The teaching of this topic important as it is also illustrates the use of pupils' experience in teaching and makes them sensitive towards the conservation of energy.

Concepts

1. Significance of other sources of energy.
2. Conversion of wind energy in to useful form.
3. Wind-mills in Orissa.
4. Use of Hydro-electricity.
5. Conditions for harnessing tidal energy.
6. Feasibility of tidal energy in India.

Testing Previous Knowledge/Alternative Concepts

Pupils know that some kind of energy either electrical or chemical in the form of fuels like firewood, kerosene, diesel, petroleum gas and petrol is needed for enjoying the modern amenities.

Some of them may think that there need not be any problem regarding energy because they have learnt that energy is neither created nor distroyed. So we should impress upon the children that energy may exist for ever but it may not exist in a form which can be used to move things and also produce heat. The situation can be explored by asking following questions:

1. What does a fan or air cooler do?
   Ans:- Cools our body and protects it from summer's heat.
2. What makes the fan move ?
   Ans:- Electrical energy.
3. Why do we take food?
   Ans:- Because we feel hungry.
4. Yes, but is it related with energy requirement of our body?
   Ans:- Yes Sir, our biology teacher has told us that we need energy to carry on the processes in our body.
5. Do we also use energy for cooking our food ?
   Ans:- Yes.
6. Name the sources from which we get this energy.
   Ans:- Kerosene, gas, fire-wood, and electricity.

Presentation

We are giving here the questions which can be asked to the pupils to bring out their experiences regarding the topic. We are also giving examples and explaining certain difficult ideas.

Developmental questions:

1. At present the fuel for cooking is
   i) Cheap and easily available.
   ii) Expensive but easily available.
   iii) Very expensive but available or
   iv) expensive yet not always available.
   Ans:- Expensive yet not always available.

2. The pupils may be asked to recall the knowledge learnt in earlier classes regarding the formation of petroleum under the crust of the earth and also regarding its composition: What are the known oils we get from petroleum?

Previous knowledge recall-Petroleum is formed from the remains of plants and animals buried under the earth through natural geological processes occurring over thousands of years.

Ans:- Kerosene diesel and petrol.

3. Why is kerosene sold in government controlled shops?

Ans:- Because the supply of kerosene is insufficient to check the possible black marketing and for equitable distribution.

4. If petroleum reserves under earth get exhausted what situation do you imagine will occur ?

Ans:- Acute energy crisis will occur.

5. When forest cover is further distroyed or the government puts a total ban on felling of tree what will happen ?

Ans:- No fire wood can be had.

6. What then do you think is expected of scientists ?

Ans:- To solve this energy crisis.

7. How do scientists think they can solve this problem?

Ans:- By discovering other sources of energy.

8. What helps inthe flying of kite ?

Ans:- The wind.

9. How does a weather-balloon move in air?

Ans:- Because of **wind current.**

10. How does the hand-pump operate?

Ans:- Due to the muscle power of hand.

11. If the handle is connected by some mechanical device which in turn is operated by wind will the hand-pump not work ?

Ans:- Yes

The teacher then states that such a mechanical device is called a wind mill. He may also take the pupils to a near by science park where the model of a wind mill is kept. If pupils have already seen such a ~~wnd~~/mill, their experience can be recalled.

12. How do some shop-owners switch on their electric lights even during the load **shedding**?

    Ans:- They use an electric generator.

13. What fuel is used to run the generator ?

    Ans:- Diesel.

The teacher then explains that a wind mill can also be used to run a generator and produce electricity.

14. In which places in Orissa do wc have wind mills?

    Ans:- Puri, Gopalpur and Konark.

15. Why do we have wind mills at these places only?

    Ans:- On the sea shore the wind speed is high and the wind is continuous.

16. Why does electricity come from Hirakud Duduma, Machkund and Indravati?

    Ans:- There are big **dams** at these places which produce electricity.

17. Describe the energy transformation taking place at the site of the dams generating hydroelectricity.

    Ans:- Potential energy of water gets converted into kinetic energy which generates the mechanical energy of the turbine connected with the generator to produce electricity.

The teacher explains the use of tidal energy:

When threre is high tide in sea, water carried by waves rushes to high reaches of he shore. At the confluence where big rivers meet the sea, the sea water rushes to long distances into the river. Even if there is not much water upstreams the region of river near the sea overflows and the water recedes alternately.

If the receding water can be stopped by building a Dyke, a huge dam can be built at low cost. Such dams utilising tidal energy can also be used to generate electricity.

18. Can tidal energy be harnessed everywhere ?

Ans:- No. It can be harnessed only where big rivers meet the sea.

19. In India where are such places?

Ans:- In Calcutta near Hoogly ad in Gujarat near Kambay and Kuch.

20. What geographical advantage India has for harnessing tidal energy ?

Ans:- It has a long coast line with big rivers
nd meeting Bay of Bengal ~~had~~ the Arabian sea.

21. How does the energy obtained from wind and tide help the society and the nation?

Ans:- It reduces our dependence on costly and non-renewable source of fossil fuel and solves the energy crisis to some extent.

Assignment for Pupils

Pupils may be asked to go to the nearest wind mi in small groups and note briefly the construction and function of a wind mill.

Related Higher Knowledge

The teacher should try tofind out more about the national efforts made towards harnessing wind and tidal energy.

Conclusion

We hope the aforesaid dealing of thetopic on other sources of energy will create a sense of appreciation among pupils about science and the efforts of scientists in averting the energy crisis. They will als be sensitised towards avoidence of wasteful use of energ in day to-day life.

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EXEMPLAR NO. 4

Name of the Topic:- Refraction of LIGHT

Level :- Class - IX

Drafted by :- Group Coordinators: Sri Achyutanand Nayak.

Group members: Smt.Rabipriya Devi,
Sri Hrudanand Mishra,
Sri Minaketan Swain and
Smt. Snehaprabha Panda.

Introduction

Refraction of light is a phenomenon which can be inferred from many day to-day illustrations like apparent bending of any straight object under water apparent rise of the bottom of any container cotaining water, rainbow in the cloudy sky and colourful sight of he fountain of water in sunlight producing the artificial rainbow. The teaching of these concepts can illustrate the application of logical and inquiry approach, skill of giving examples and organising demonstration and activities. In what follows we are making an attempt at this task.

Concepts

i) Bending of light beam at the interface between two homogeneous media is called refraction.

ii) The incident ray the normal to the interface at the point of incidence and the refracted ray lie inone plane.

iii) The sines of the angles of incidence and refraction bear a fixed ratio characteristic of the pair of media.

iv) Velocity of light is different in different media and also different for different colours.

v) The angle of incidence in the denser medium for which the angle of refraction in the rarer medium is 90 degrees is called the critical angle for the pair of media.

vi) When the angle of incidence in the denser medium exceeds the critical angle the ray is totally reflected in the denser medium.

vii) Spreading of white light into a spectrum of colours on refraction is called dispersion.

Previous Knowledge/Alternative Concepts

Pupils know the rectilinear propagation of light in a homogeneous medium and the laws of reflection. The pupils may think that the prism adds colours to white light instead of splitting the colour already present in white light.

Presentation

The teacher will pose a problem to the pupils as follows. Hewill ~~partly~~ immerse any straight object like a pencil partly in water in an inclined manner and ask the pupils to observe the apparent bend in the object at the surface of water. Then he would provoke the pupils to think about the explanation. The teacher will now take a beaker and allow a narrow pencil of strong torch light in an inclined manner inside an empty beaker and mark the point where the beam falls inside the beaker with a mark which does not get dissolved in water. Without changing the position of light relative to the beaker he would ask another pupil to fill the beaker with water and the pupils would see for themselves that now the light falls at a different point inside the beaker. Thus demonstrating the bending of light at the surface of water directly.

Teacher will now lead the students to investigat the similar phenomena in solid transparent substance like glass slab. Depending on the availability of materials he can demonstrate or organise group activities regarding the Pin-Board experiment. He will explain to the pupils that the incident and emergent rays are defined by the pins fixed on the board but the refracted ray is inferred. From this experiment it can be inferred that (sin i/sin r) is always a constant for all possible angles of incidence. Pupils will also learn from this experiment that light bends towards the normal when it passes from rarer medium like glass and away from the normal when light passes from denser to the rarer medium.

At this stage the teacher will explain to the pupils that the phenomenon of refraction occurs because light has different velocities in different media. This is so because light is nothing but an electromagnetic wave and every material medium is electrical in nature. He will also inform the pupils that the velocity also depends on the wavelength hence on the colour of light. This is the reason why white light of sun gets split into colours by a prism or tne raindrops causing the occurrence of rainbow.

Next the teacher would make the pupils imagine a a ray of light going from the denser medium to a rarer medium and ask him the relationship between the angle of incidence, i and angle of refraction, r for any non-zero angle. They would easily agree that $r > i$ by drawing a suitable ray diagram. Now they would be asked to predict what would happen as the angle of incidence is gradually increased. They would conclude that at some angle of incidence the angle of refraction would become 90 degrees the highest possible angle if the light has to enter the rarer medium. This particular limiting angle of incidence for which the angle of refraction in the rarer medium is 90 degrees will be defined as critical angle for the pair of media by the teacher. Now the teacher will state and the pupils would also see that for a larger angle of incidence the refracted ray will not be possible and the ray will be totally reflected. Pupils will be given the home task of explaining the phenomenon of mirage as illustration of total internal reflection.

Assignments for Pupils

1. Draw the diagrams for cold and hot mirage and explain their difference.

2. It is said that we see the rising sun a little earlier than when it physically rises above the horizon. Explain. What phenomenon is expected regarding the setting sun.
3. Why do the air bubbles inside a paper weight shine so much ?

Related Higher Knowledge

The teacher may try to understand the explanation of the phenomenon of refraction on the basis of Wave theory of light and try to think of the teaching aids or anologies by which this can be explained to the pupils.

Conclusion

In this unit we have hilighted the use of inquiry and logical approach to promote logical thinking in children. Some interesting experiments are also discussed so that the pupils develop the curiosity to experiment in real life.

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EXEMPLAR NO.5

Name of the Topic :- Chemical Bonding

Level :- Class - IX

Drafted by : Group Coordinators: Sri Achyutanand Nayak

Group members: Smt. Rabipriya Devi,
Sri Hrudanand Mishra,
Sri Minaketan Swain,&
Smt. Snehaprabha Panda.

Introduction

About 112 elements and a large number of naturally occurring and artificially synthesised compounds are available around us and we use them in our daily life for various purposes. Each of these have a chemical formula, structure and properties of its own. We are well aware of the properties but their correlation with their respective structures can be better understood if we learn about the types of bonding between the elements constituting the molecule of the substance. In order to teach this topic mostly the logical and inquiry approaches and the skills of explaining, organising activities and giving examples can be illustrated.

Concepts

i) Atoms have a tendency to have 8 electrons in their outermost shell (octet rule).

ii) Atoms not having stable octet can achieve this either by donating or accepting electrons.

iii) Atoms on donating electron become positively charged and is called +ve ion and the atom on accepting electron become negatively charged and is called as -ive ion. These oppositely charged ions attract each other and form ioninc compounds.

iv) Covalent bonds occur when atoms share electrons.

v) Compounds with ionic bonds and those with covalent bonds have different properties.

vi) Distance between nuclei of the two approaching atoms where the forces of attraction and repulsion are balanced determine the length of the chemical bond.

vii) Lowering of potential energy that results due to simultaneous attraction of electrons by the nuclei of combining atoms leads to bond formation.

Previous Knowledge/Alternative Framework

It is assumed that pupils know fundamentals of atomic structure, names of the various elements and compounds, electronic configuration of various elements and that noble gases are stable and nonreactive. Pupils may have a misconcept that atoms of any two elements can combine to form a compound.

Presentation

The teacher will explain the cause of the inertness of noble gases as follows. He would invite the pupils to suggest names of some common elements and write these on the board. Then he would ask them to find out the electronic configuration of each of them and write this on the board as well as in the notebooks of the pupils. Now he will encourage them to find out the similarity of the configurations of inert gases and make pupils note the difference with other elements. With some discussions and a few mistakes here and there the pupil will be able to generalise that octet rule is applicable to all the inert gases and they may hypothesise that octet formation is the cause of their inertness.

Next the teacher will ~~aks~~ the pupils to state the electronic configuration of sodium and chlorine and make them think how these atoms can achieve the octet of electrons in their outermost shell. He will phasize at this point that sodium atom and chlorine tom are both very reactive and therefore do not tay in free state whereas the Na ion and Cl ion remain table in solution of sodium chloride and also conduct lectricity. He will also explain that in sodium chloride hese ions of sodium and chlorine are held together due to the electrostatic force of attraction between them.

Similarly for teaching Covalent bond example of water molecule can be taken. To clarify the concept of length of the chemical bond the teacher will recall the knowledge of the pupils regarding structure of atom. Giving the example of hydrogen atom he will explain that it contains a positively charged nucleus and an electron. When two hydrogen atoms approach each other there are attractive forces acting between electrons and protons and repulsive forces acting between the two protons and the two electrons. Pupils may be encouraged to calculate these forces and to c comment qualitatively as to how they increase or decrease. He may draw a diagram on the board and state that bond length is that distance for which these opposing forces balance.

To familiarise the pupils with the properties of ionic and covalent compounds some demonstration experiment or activities can be arranged on following:

i) solubility of different compounds in water, benzene, ether and kerosene;

ii) conduction of electricity;

iii) effect of electrolysis;

iv) melting point

After doing the experiments themselves or observing the demonstration experiments pupils will be encouraged to draw their own conclusions.

Asignments for Pupils

1. Name 5 ionic and 5 covalent compounds.
2. Illustrate by drawing the octets the bond formation between two oxygen and two nitrogen atoms.
3. Explain the nature of chemical bonding in the chemicals bearing molecular formulae: $MgCl_2$, HCN, C_6H_6 and H_2O_2.
4. Give the reasoning in one sentence for:
    - i) carbon tetrachloride has low melting point
    - ii) sodium chloride has high melting point
    - iii) OH is very reactive but not H_2O
    - iv) Na is very active but not NaCl
    - v) Na_2 and He_2 molecules are not found
5. Which of the following will be most reactive ?

    CH_3, CF_3, CHF_3 and CH_2F_2

Related Higher Knowledge

The teacher should try to acquire more knowledge and understanding about the lowering of energy during bond formation and think of anologies to convey the same to the pupils in an elementary way.

Conclusion

Here we have tried to illustrate how by proper questioning relevant data can be extracted from the pupils and the same can be utilised to further the learning process leading the pupils logically to the desired conclusions. Experiments have been just listed and the details are not given as the names of the experiments are suggestive enough. The teacher who will try these experiments in the classroom will be in a better position to react on the feasibility and the difficulties encountered.

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EXEMPLAR NO. 6

me of the Topic :- Structure of Atom

vel :- Class - IX

rafted by :- Group Coordinators: Sri Achyutanand Nayak

Group members: Smt. Rabipriya Devi,
Sri Hrudanand Mishra,
Sri Minaketan Swain &
Smt. Snehaprabha Panda.

Introduction

The science of Chemistry deals with the world of matter. Different matter behaves differently. It is due to their different atomic structure. As a scientifically literate person every one should have an elementary idea of the theory of atomic structure. This is the reason why this topic is included in the secondary school curriculum. All agree that the teaching of atomic structure is difficult at secondary level because of the abstract nature of the subject and also because it is difficult to use any teaching aid. In what follows we are listing some simple experiments which can be done by the pupils using low-cost/no cost materials and some others whose only description can be given to the pupils. Mostly the logical and inquiry approaches and the skills of explaining and giving examples are used.

Concepts

i) Matter is electrical in nature.
ii) Atom consists of electrons, protons and neutrons.
iii) All the positive charge and mass of the atom is concentrated in a relatively 100,000 times smaller extent of space known as nucleus.

Previous Knowledge/Alternative Framework

The pupils are aware of the different properties of matter which they use and may know some correct and some incorrect explanations based on the layman's knowledge of atomic structure. They may think that the electric charge generated during friction between two surfaces of matter is not due to redistribution of electrons of the two objects but may be coming from somewhere else. They might also think that frictional electricity is produced only in the case of glass and ebonite rods and cat skin and silk cloth.

Presentation

We can ask our pupils to collect pieces of plastic, used pens, broken scales, and many such solid materials, some of them could be metal pieces as well and some cloth-like waste material may be of cotton, nylon, silk and plastic and bits of very light paper or thread or wood-straw. They may be asked to rub any two things together and bring these things after rubbing near small bits of paper and note down their observationsin a tabular form. This can be conducted as group activity by a groups of three or four pupils and their observations should be compiled by the teacher. Adding his own explanations and information the teacher should then help the pupils generalise that all matter is electrical in nature and that a very light particle called electron is the constituen of all matter. Some experiments with balloons and by rubbing of dry mustard seeds on a plastic plate on a dry day should be demonstrated to show the repulsion between like charges.

For giving other concepts of atomic structure w can just describe the experiments done by scientists in the laboratory and help the pupils to develop the concepts in a fruitful and correct manner. The experiments that we should discuss are: i) electric discharg in a glass tube containing any gas at low pressure describing how cathode rays which are nothing but electrons and positive rays which were nothing but the ions or protons, the nuclei of hydrogen atom if the gas chosen is hydrogen. The teacher should allow the pupils to question these experiments and try to satisf their queries in a logically convincing manner: (i) Rutherford scattering experiment of alpha particles which are nothing but helium nuclei from gold foil, the teacher should explain by making use of anologies how this necessitates the postulate that the mass and charge of the atom must be concentrated in the nucleus; and (iii) Chadwicks experiment on the discovery of neutron.

Assignment for the Pupils

1) In the activity conducted by you on frictional electricity you must have found attraction of the bits of paper or no action. What should you do to see repulsion in the same experiment ?

2) Sometimes our dry hair when combed stand erect. Is it due to attraction or repulsion? Explain this occurence using the term 'electrons'.

3) What can you say about the shape of (the simplest) hydrogen atom as the scientists tell us ?

i) like a dumbell
ii) like a ring
iii) like a plate
iv) like a ball

Related Higher Knowledge

The teacher should try to understand more about the modern concept of atom and think of analogies and examples to convey these ideas to the pupils in a simple manner.

Conclusion

While writing this exemplar we have kept two things in mind. Firstly we have not given the details of those things which can be easily found in books at intermediate level; and secondly this topic was also discussed by the resource faculty and so we have tried to avoid repetition. The feedback of the teachers who would try out some of the ideas given here will be very useful. Finally we would also like to say that this particular unit truly signifies the tentative nature of science hence all attempts of giving prto-type answers to the queries of pupils should be avoided and instead the pupils should be encouraged to read for themselves and discuss among themselves the ideas postulated in the theory of atomic structure.

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EXEMPLAR NO. 7

Name of the Topic :- Force and Acceleration

Level :- Class IX

Drafted by :- Group Coordinator: Dr.J.P.Sharma
Group members: Sri Arun Kumar,
Sri Kaushal Kishore Sharma, and
Sri Arun Kumar Singh

Introduction

In our everyday life we see things like trains, buses other vehicles, animals and birds starting to move, move and then again stop. So we see that the speed of things either decreases or increases. These phenomena are called as decelerations and accelerations in science. Why do things decelerate or accelerate? The external agency which does this to a body is called the force acting on a body. In what follows we state the various concepts related to force and acceleration relevant to science at secondary level, explain the details involved and discuss how these concepts can be put across to the pupils. Mostly we are describing the demonstrations which a teacher can give in the class and state the questions he would ask to use in teaching, the experiences of the pupils.

Concepts

i) Force and its relation to motion
ii) Balance and unbalanced forces
iii) Momentum
iv) Relation between Force and acceleration.

Previous Knowledge/Alternative Framework

In earlier classes pupils have studied the concepts of distance, displacement, uniform and nonuniform velocity. They would have also solved the kinematic problems on uniform accelerationand they have some idea about force as push or pull as learnt at primary level and their own ideas about force unknowingly developed because of their involvement in day to day activities where laymen use the term force with a varied sense exemplified by the usage like 'I do not have much force left with me now'. These form some of the misconcepts also called alternative framework which every pupil brings with him in the class. As a science teacher we should try to find these out and with the help of demonstration, activities and questioning try to remove them. Some such common misconcepts are:

i) Force is associated with the body throughout its motion.

ii) A single force can change the shape of the body.

iii) Force acts in the direction of the velocity of the body.

iv) There is no force acting on the body when the velocity of the body is zero.

Presentation

1. Force and its relation with motion:-

The teacher will place any object on the table and leave it for a couple of minutes and then ask the pupils questions regarding its state of motion. The pupils will respond that the object remains where it was kept; it has no motion; its speed is zero and its acceleration is also zero. The teacher will define this has a state of rest. Next he will push the object for a moment with his left hand and again ask the pupils questions about the state of motion of the object. They will answer that the object gained some speed, the teacher will state the first characterist of the force that force, in this case the push of the hand, changes the speed of the object.

Teacher will hang a ripe banana with a string and ask a few pupils one by one to change its shape using only one finger. All pupils will realise that it is not possible to do so. Next he would ask them to change its shape using thumb and the finger. Pupils will see that now they can change the shape of the banana. The teacher will state that it requires more than one force push or pull to change the shape of a body and introduce the idea that forces can also change the shape of a non rigid body.

Teacher will ask one of the pupils to roll a ball towards him. As the ball is rolling towards him he will first put his hand inclined to the motion of the ball and ask the pupils following questions:

1. When the ball hit the hand did it come to rest ?
   Ans:- No
2. If it was moving as describe any change in its motion.
   Ans:- It changed its direction.

Next he would keep his hand normal to the moving ball and the ball would stop. Again by similar questioning pupils would realise and the teacher will state that force changes the direction of motion of the body or reduces its speed and brings it to rest.

Now through further questioning the pupils will be helped to draw the conclusions regarding the effect of force on the motion of a body. It should be ensured that the misconcepts of as far as possible all pupils regarding the concept of force are erased and the correct concepts formed. For this a wide variety of questioning to as many students as possible is necessary. Some models of such questions have been discussed by the resource faculty. Hence these are not mentioned here to avoid repetition. It would suffice to say that from the small demonstrations given earlier the pupils will be able to state that force is needed only to change the velocity and no force is needed to maintain constant velocity of a body. An example can be given from our daily life that while riding a bicycle we first start pedalling (apply force) to get it in motion. After it gets motion and we feel ourselves to be tired we stop pedalling (do not apply force), but the bicycle does not stop. It remains in the state of motion for sometim But when we feel that it is losing speed (due to the frictional force between its tyres and the road we again start pedalling (apply force). Another misconcept regarding whether a single force can change the shape of a body should be removed by the example of the ripe banana given earlier.

2. Balanced and unbalanced forces:-

Teacher will take a wooden block tied with two strings to the opposite faces and explain by demonstrating that if the block is pulled by one string it moves in one direction and when it is pulled by another string it moves in the opposite direction. But if it is pulled simultaneously by both the strings with equal effort the block does not move at all. So with some more widely distributed questioning pupils can conclude that two equal and oposite forces acting on the same body form a pair of balanced forces and under their effect body does not change its state of motion. But when these forces are opposite but unequal the left out unbalanced portion of one of the forces changes the velocity of the body.

3. Momentum:-

By giving example from every day life the teacher will convince the pupils that the amount of motion in a body not only depends on the velocity of the body but also on its mass. A bicycle hitting an object produces much less motion in it than a loaded truck hitting the same object with equal speed. The teacher would then define momentum as a product of mass and velocity.

4. Relation between Force and Acceleration:-

The teacher will state that according to the Newton's second law of motion we can define the force quantitatively and relate it with acceleration produced in the body as under. The teacher will explain by writing on the board as follows:

Force, F (mv - mu)/ t (rate of change of momentum)

or F = k.m.(v-u)/t), where k is proportionality constant which defines the unit of force.

or F = m.a where a is acceleration and the unit of force is so chosen that k = 1.

He will define unit force as that which produces unit acceleration in unit mass and state that force is a vector quantity because acceleration is a vector quantity.

Assignment for Pupils

Pupils can be given following assignments:

1. A rectangular block of mass M is resting on the floor. Name and raw the forces acting on the block and the floor. Which of them form the pair of balanced forces.

2. The following is the distance time table of an object moving in a straight line;

Time in seconds	Distance in metres
0	0
1	1
2	8
3	27
4	64
5	125
6	216
7	343

What conclusions can you draw regarding the acceleration of the object? Is it constant increasing decreasing or zero? If the mass of the object is 1 kg what is the force acting on the object after 4 seconds ?

Related Higher Knowledge

The teacher should try to think why the misconcepts regarding the concept of force occur and try to devise newer techniques to avoid them as discussed by the resource faculty.

Conclusion

Force is a concept included in the curriculum from grade 3 to master's degree. Therefore, it is very important to predecide the scope and sequence of the various aspects to be covered at secondary level. Special care has to be taken to erase the misconcepts already formed and prevent the formation of further misconcepts. Lot of feedback from teachers teaching this topic is essential for further improvement of teaching in the classroom. Needless to say that the teachers should also discuss among themselves regarding the method as well as the content of this important topic.

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EXEMPLAR NO.8

Name of the Topic:- Gravitation

Level :- Class - IX

Drafted by :- Group Coordinator: Dr.J.P.Sharma
Group members: Sri Arun Kumar,
Sri Kaushal Kishore Sharma,&
Sri Arun Kumar Singh

Introduction

The force of gravitation is all pervading in the universe since its existence. This is the force which holds the universe and makes the galaxies go round each other, stars of the galaxy to be contained in the galaxy and the star like sun hold on their planetary system to itself. The idea that the force which is responsible for all this was a force acting between all objects possesing mass first occured to Sir Issac Newton and hence it is called Newton's Universal law of gravitation. The teaching of this topic is very interesting and illustrates the use of logical and historical approaches and involwes the skills of explaining, questioning and giving examples.

Concepts

i) Universal Law of Gravitation
ii) Gravitational Constant
iii) Force of gravitation between different bodies
iv) Weightlessness of a body.

Previous Knowledge/Alternative Framework

Pupils are expected to know the relationship between force and acceleration and Newton's third law of motion. They may have a misconcept that mass and weight are the same things and that force and acceleration are independent of each other.

Presentation

Take any object in your hand and leave it and ask the pupils to observe carefully and answer the following questions:

1. What did you see?
   Ans:- The object is falling or in motion.
2. What was the velocity of the object when it was inhand and at the instant it was dropped?
   Ans:- It was zero.
3. Was the velocity of the stone increasing or decreasing while it was reaching to the ground?
   Ans:- It was increasing.
4. Was the motion of the stone accelerated then?
   Ans:- Yes.
5. Can we conclude from this that there should be some force acting onthe object?
   Ans:- Yes.
6. By which law you say yes?
   Ans:- Newton's second law of motion.
7. What is the direction of force acting on the object?
   Ans:- Downwards.

The teacher will then emphasise that whenever there is acceleration of the object some force has to be responsible for it. This fact was known to every body when Newton gave the law of gravitation. But Newton postulated correctly that the force due to earth which produces acceleration in moon is also the same force which attracts objects over the surface of earth towards it. It is said that an apple fell on Newton's head and he got the idea. We do not know of the truth of this story although Newton had an orchard in his house. What we know from the records is that Newton compared the observed acceleration of moon with that of any object (may be apple as well) and found that this ratio is the reciprocal of the ratio of the squares of the observed distance of the moon and the experimentally estimated radius of the earth. This curious fact most probably made him ennunciate the universal law of gravitation as under:

" Any two point particles or spherical objects of masses M and m situated at a distance of r any where in the universe, attract each other with a force which is directly proportional to the product, 'M.m' of the masses and inversely proportional to the square, 'r' of the distance between them. "Mathematically it is stated as:

$F \propto (M.m) / r^2$ or $F = G. (M.m/r^2)$, Where G is called the universal gravitational constant and is independent of M. m and r.

While stating this law and getting it recalled by the pupils the rigour regarding the terms 'point particle' or 'spherical objects' should be emphasised. It can be stated that only in these cases the distance between the objects can be easily and uniquely defined. Also pupils usually understand any increasing relationship between two variables as 'directly proportional' and any decreasing relationship as 'inversely proportional'. This misconcept should be identified and replaced by the correctly worded statement such as F is directly proportional to M.m means that if M.m is increased then F increases by the same proportion and so on. Another thing which needs our attention as teacher, is the fact that the gravitational force between any two commonly encountered objects on the earth is not large enough to be perceived. In this connection Cavendish's experiment given in the text books should be described or the pupils be given a proper home task regarding this. As a follow up of this and other numerical problems the teacher can then state the value of G as 1.068×10^{-7} N. m^2 kg^{-2}

We should use Newton's third law of motion to convince the pupils that when earth pulls any object towards itself at the same time the object is also pulling the earth with equal force. Pupils can calculate the acceleration produced in earth due to this force and see for themselves how small it is (1.65×10^{-24} gms^{-2}). The another concept which baffles pupils with regatd to gravitation is the concept of weightlessness experienced in the satellite. In this regard following explanation can be given:

"Weight is normally defined as the force exerted by the earth on the object it is better defined as the action of the object against the floor. Let $\bar{F}_w$ be the weight of the man of mass M, standing on the floor. Because the object is at rest (that is acceleration is zero) the net force acting on the object must be zero. Let $\bar{F}_e$ be the force acting on the object due to the earth. According to Newton's third law the force exerted by the floor on the man is $-\bar{F}_w$. Hence,

$$\bar{F} = 0 = \bar{F}_e - \bar{F}_w \text{ that is } \bar{F}_e = \bar{F}_w = M.\bar{g}$$

This expression for $\bar{F}_w$ matches with the normal definition of weight. Now assume that the floor is going down with an acceleration '$\bar{a}$'. In this situation we have,

$$\bar{F} = M.\bar{a} = \bar{F}_e - \bar{F}_w = M.\bar{g} - \bar{F}_w \text{ or } \bar{F}_w = M.(\bar{g} - \bar{a})$$

As a result the reaction due to floor, ~~floor reduces~~ and if one is standing on such a floor one feels light. When g = a the reaction of the floor becomes zero and the weight of the object experienced in the freely falling lift becomes zero. If you are in such a lift and drop sum object it will be just floating in front of you because both you and the object are falling towards the earth at the same rate with same acceleration. This is what happens in the satellite. The pupils can be given home task to explain this.

Assignments for the Pupils

1) Assuming orbit of the moon as circular and its time period as 28 days calculate it centripetal acceleration. You will have to take the distance of the moon from the textbook. Compare this acceleration with that found on earth. Interpret your result.

2) Criticize the statement: 'We feel weightless in the satellite because we are far away from the earth' .

Related Higher Knowledge

One can interpret the weightlessness using the concept of psuedo force. Discuss this with your colleagues and help the gifted pupils who may express their inclination in understanding it that way.

Conclusion

Here we have tried to illustrate how so called lecture method can be made interesting with the help of questions, clear explanations, home tasks and by following logical and historical approaches. The feedback of the teachers following this strategy will be very useful for improving it further.

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EXEMPLAR NO.9

Name of the Topic :- Oxidation Reduction Reaction

Level :- Class - X

Drafted by :- Group Coordinator: Dr.J.P.Sharma,
Group members: Sri Arun Kumar,
Sri Kaushal Kishore
Sharma and
Sri Arun Kumar Singh

Introduction

Chemical reactions are taking place all around and inside us every moment. Some of them are rusting and burning outside us and respiration and digestion inside our own biological system. ~~Every~~ chemical reactions ~~is~~ governed by loss or gain of electrons. These two processes help us in giving it a name of oxidation-reduction reaction. Teaching of this topic involves inquiry approach, and the skills of explaining and giving examples and organising simple demonstration experiments on the part of the teacher.

Concepts

i) Oxidation and reduction
ii) Oxidation number
iii) Interpretation of oxidation-reduction reactions in terms of loss or gain of electrons.
iv) Redox reaction.
v) Balancing of redox reactions

Previous Knowledge/Alternative Framework

Pupils are expected to know the electron configuration of elements and about the valence electrons which take part in chemical reactions. They are also aware of electron affinity and electronegativity of elements. They might be having the misconcept that oxidation reaction are addition of oxygen and reduction reaction are removal of oxygen.

Presentation

The teacher will burn a small piece of Magnesium ribbon, ask the pupils to observe and write the chemical equation for the same in their notebooks. Teacher will also write as follows on the board:

$$2\,Mg + O_2 \text{ ------------- } 2\,MgO$$

and state that here we see that oxygen is added to magnesium to form magnesium oxide and liberate some energy. Giving another example he will state that when zinc is heated with cupric oxide following reaction takes place:

$$CuO + Zn \text{ ------------- } Cu + ZnO$$

He will explain that here oxygen is removed from cupric oxide and is added to zinc to form copper and zinc oxide. Giving yet another example he will write the chemical equation for the reaction of hydrochloric acid on zinc:

$$Zn + 2\,HCl\,(dil) \text{ ----------- } ZnCl_2 + H_2$$

As these three equations remain on the board he would ask the pupils:

1) What is the common thing happening to the elements magnesium in the first and zinc in the last two reactions? With some prompting they will be able to state that they all lose electrons to become corresponding ions. Here the teacher will introduce the concept of oxidation number stating that the oxidation number of the element losing an electron increases by one and that of an element gaining an electron decreases by one.

2) State other reactions in which the elements lose electrons. Pupils may state some examples. The teacher will ask further questions on these such as, where these electrons are going and which element is gaining electrons and so on.

3) On his own the teacher may state another popular example of the Cu-Ag voltaic cell and write the chemical equations representing the chemical reactions as,

$\mathrm{Cu\ (s) + 2\ Ag^{+}\ (aq)}$ -------- $\mathrm{2\ Ag\ (s) + Cu^{1+}\ (aq)}$

Or $\mathrm{Cu^{o}\ (s)}$ ----------- $\mathrm{Cu^{2+}\ (aq) + 2\ e^{-}}$, and for Ag

$\mathrm{2\ Ag^{+}\ (aq) + 2\ e^{-}}$ ------- $\mathrm{1\ Ag^{o}\ (s)}$

and explain the mechanism of an electrochemical cell. With some more questioning and giving some more examples or by asking pupils to give examples the teacher can help the pupils to draw the following conclusions:

1) The addition of oxygen to, or removal of hydrogen from an element resulting in the loss of electron or increase of oxidation number is defined as the oxidation of the element and the addition of hydrogen to, or removal of oxygen from an element resulting in the gain of electron or decrease of oxidation number is defined as the reduction of the element.

2) Oxidation and reduction take place simultaneously in a reaction. If one element is oxidised then the other element is reduced. Hence these reactions are also called as redox reactions.

3) The substance which accepts electrons during chemical reaction is called as an oxidising agent and the substance which donates electrons is called as reducing agent.

Assignment for the Pupils

1) Name the oxidising and reducing agents in the following reactions and also identify the elements getting oxidised and reduced in each of the reactions:

i) $\mathrm{H_2S + Cl_2}$ ----------- $\mathrm{2\ HCl + S}$

ii) $\mathrm{Zn + CuSO_4}$ ----------- $\mathrm{ZnSO_4 + Cu}$

iii) $\mathrm{2\ KI + Br_2}$ ----------- $\mathrm{2\ KBr + I_2}$

2. Give an example of a substance which acts both as oxidising and reducing agent. State the necessary chemical equation to explain.

Related Higher Knowledge

Teachers should try to discuss with their colleagues the concepts of electrode potential and electrochemical series and help the pupils to learn more about the prediction and feasibility of precipitation of substances in a chemical reaction as an application of redox reactions.

Conclusion

We have tried to present here in brief the demonstration experiments and the examples and questions to be asked to the pupils while teaching the topic of redox reactions. The feedback from the teachers who use this strategy will be useful in improving it or modifying it further.

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EXEMPLAR NO. 10

Name of the Topic:- Ohm's Law Verification

Level :- Class - X

Drafted by :- Group Coordinator: Dr.B.B.Panda
Group members: Dr.(Mrs) Purnima Das,
Sri B.Ganapati Achary
and Sri Surendra Patn

Introduction

This is the age of science and electricity being its most useful invention, we are all surrounded by electric and electronic gadgets in homes, offices factories, hospitals and schools. Ohm's law is operating in almost all electric and electronic instruments we can think of. We illustrate here the use of analogies to give electrical concepts and how to use laboratory to teach the verification of Ohm's law.

Concepts

i) Electric potential
ii) Electric current
iii) Ohm's law as relationship between the two for a given conductor.

Previous Knowledge/Alternative Framework

The pupils are aware of the concept of potential in mechanics and of the fact that water flows downhill. They also know that conductor contains free charges in the form of electrons. They may have the misconcept that the current flowing in a low resistance connected in series with a high resistance is lower than that flowing through the high resistance.

Presentation

Giving the anology of water or by actual demonstration of water flow from higher level to lower level the teacher will explain that similarly the electrons present in a conductor move when its two ends are kept at different potential. He will take a dry cell, a torch bulb and a piece of wire and demonstrate the flow of current in the form of the lighted bulb. He will emphasise that although conventionally we say the current flows from positive pole of the battery to the negative pole in the outer circuit, the electrons being negatively charged move in the opposite direction. He will then put two cells in the circuit and show that the bulb glows more and the pupils will themselves say that increasing the potential across the conductor increases the current flow. By this simple demonstration pupils will be curious to know what is the relationship between potential difference across and the current flowing through the conductor. He will then state the Ohm's Law as:

Other physical properties like temperature remaining constant, the current flowing through a conductor is directly proportional to the potential difference applied at the ends of a conductor.

Showing them different gadgets required for the verification of this law he will explain their functions. For example the battery applies potential difference, the voltmeter and ammeter measure the potential difference and the current, and the rehostat controls the current in the circuit. He will explain to them what precautions are to be taken in connecting them and then he would ask them how to connect them in order to verify the Ohm's law. He will discuss the desired connections on the board first. When he is satisfied that the students understand the circuit diagram and the functions of each instrument he will take their help to connect the circuit as follows. At this stage the teacher would ask the pupils as to where else the ammeter can be connected so that the result and even the reading of the ammeter is not affected. This is essential to impress upon the pupils that the current flowing in a series circuit is the same for all positions of the ammeter.

Then he will call students in batches and ask them to take the readings V and I of voltmeter and ammeter respectively for different settings of the rehostat.

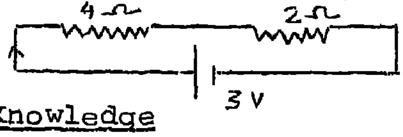
He would tabulate these on the board and also ask the pupils to note down in their notebooks. The pupils then calculate the ratio V/I and verify that it is constant within experimental errors. The teacher will state that this ratio is called the resistance R of a conductor He can also encourage them to plot these values on a graph and verify that it is a straight line.

At the end he would state that if we do similar experiment for a bulb and pass such current till it starts glowing then the ratio of V and I will not appear to be a constant and also the graph between V and I will not be linear. So Ohm's Law does not hold good here because the temperature of the filament is obviously not constant.

Assignment for the Pupils

i) What is the resistance of a conductor which carries 1.5 A current when it is connected to a source of three batteries giving altogether a potential difference of 7.5 V ?

ii) What are the currents flowing and the potential differences across the two conductors in the following circuit ?



Related Higher Knowledge

The teacher should discuss with his colleagues the random velocity and the drift velocity of electrons in a conductor and relate these concepts with the Ohm's law and think of anologies to explain these concepts to the pupils.

Conclusion

We have tried to explain how anologies and laboratory materials can be used for teaching the verification of Ohm's law. The teachers who use this method in the classroom can better state the difficulties experienced. These then can be taken into consideration to improve upon our teaching.

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EXEMPLAR NO.11

Name of the Topic :- Magnetic Poles

Level :- Class - X

Drafted by :- Group Coordinator: Dr.B.B. Panda
Group members: Dr.(Mrs)Purnima Das,
Sri B.Ganapati Acharya
and Sri Surendra
Pattanayak.

Introduction

The phenomenon of magnetism is being used in all appliances in our daily life. A bar magnet is a simple device to produce the magnetic field. Here we illustrate the use of logical and historical approaches and the skills of demonstration, organising activities and discussion, and questioning for teaching a small topic related to the magnetic poles of a bar magnet.

Concepts

i) Poles are points in the region near about the two ends of a magnet which can be said to have the maximum power of attrac-tion.

ii) The pole pointing towards geographic north is called the north pole N, and that pointing towards geographic south is called the south pole S.

iii) The line NS joining the two poles is called the magnetic axis.

iv) The distance between the two poles is called the magnetic length or effective length of a magnet.

v) The magnetic length is less than the geometric length since the poles are not exactly at the ends.

vi) Neutral region is the central region of the magnet where the power of attraction is almost zero.

vii) A magnet retains its polarity even up to molecular stage.

Previous Knowledge/Alternative Framework

Pupils know that magnets attract iron pieces and orient in North south direction. They also know that though magnets are made of iron and steel, all iron or steel bars do not behave like magnets. Magnets are available in the market of all sizes and shapes. The free ends of a magnet has more attracting power than the central region. They may have the concept that the magnetic axis of the magnet is the same as its symmetry axis. They are also aware of the magnetic effect of electric current.

Presentation

The teacher will explain to the pupils that the fundamental cause of magnetism being closed electric current loops which have north pole on one face and the south pole on the other face north and south pole always occur together and can never be isolated. All experimentals to observe magnetic monopoles have up till now failed. The connection between magnetism and electricity was not known when this mysterious effect of certain objects attracting other light iron objects was first discovered. Scientists and Philosophers at that time considered magnetism to have an independent existence. So people thought that they can break a magnet and separate its two poles. But when they tried this they found that the two pieces so obtained again are magnets having two poles. Today we know that every molecule of a magnetic substance is a tiny magnet because of the motion of electrons in it. In an ordinary substance they are so arranged that the total magnetic effect is zero. But in magnets many of these tiny magnets are oriented end to end and parallel to each other so as to produce magnetic effect only at the ends and no effect in between where opposite poles are together as shown in the diagram below.

N-S-N-S-N-S-N-S-N-S-N-S-N-S-N-S-N-S-N-S-N-S-N-S-N-
N-S-N-S-N-S-N-S-N-S-N-S-N-S-N-S-N-S-N-S-N-S-N-S-N-

N-S-N-S-N-S-N-S-N-S-N-S-N-S-N-S-N-S-N-S-N-S-N-S-N-
N-S-N-S-N-S-N-S-N-S-N-S-N-S-N-S-N-S-N-S-N-S-N-S-N-

The teacher will explain that the actual situation may not be so systematic and hence the point of maximum attraction may not lie at the centre of the end. At this stage it should be explained to the pupils that the concept of a pole is abstract and it is defined as that point where the magnetic effect of the end can be assumed to be concentrated. To connect this definition with an experiment or in other words to operationalise this definition pupils should be encouraged to draw the lines of force of a bar magnet using the tiny compass needle. After such a diagram is ready the teacher will ask the pupil to make an hypothesis about the location of a single point from which all these lines can be assumed to be coming from or in other words the point where all these lines will meet. Two such points for the two ends of bar magnet are known as its poles. The teacher will then define the effective length of the magnet as the distance between these points. From the plot of the lines of force the pupils will also conclude that the central region of the magnet has less magnetic effect because he will find that these lines are most crowded at the ends and are very much apart at the centre.

Related Higher Knowledge

The teacher should study the domain theory of ferromagnetism and devise means of transmitting this knowledge to the inquisitive pupils. He should also study the connection of electricity and magnetism in more depth and think of devising simple experiments to illustrate this connection. He should also study the origin of magnetism of earth and convince pupils that there is no hidden magnet in earth.

Assignment for pupils

1. Take any ordinary piece of iron such as a key near a very tiny compass needle which is used for plotting lines of force. Observe carefully and explain them in terms of who attracts whom? Is there any repulsion? Why not? What will you do to demonstrate repulsion?

2. Take any stainless steel blade. Even an used one will do. Float it on water contained in any glass or plastic container by gently dropping it on the surface of still water with any of its face downward. It floats because of surface tension. When it becomes steady disturb it a little by any non magnetic stick. Observe carefully what happens. Repeat this activity with as many blades as possible. Give your interpretati of the experiment if we assume that each blade is a very weak magnet, what can we say about their respectiv magnetic axes? Can we demonstrate repulsion and attraction both with two blades? Why does the blade not orient when suspended freely in air as other magnets would? Discuss.

Conclusion

We have tried to illustrate here how a small concept can be taught in a very effective and interesting manner and how different processes of science including even discovery (ref. - activity regarding the blade) can be inculcated among the pupils by simple activities by a resourceful teacher. Feedback of the teachers who will actually follow this approach with their pupils will be most useful and they in turn can give some more new ideas for teaching the concepts regarding the magnetic poles.

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EXEMPLAR NO. 12

Name of the Topic :- Concept of Work
Level :- Class - IX
Drafted by :- Group Coordinator: Dr.B.B.Panda
Group members: Dr.(Mrs) Purnima Das, Sri B.Ganapati Acharya and Sri Surendra Pattanayak.

Introduction

In every day life pupils come across many situations wherein objects change their states of motion. That is if an object is at rest it may acquire motion or may just move from one position to other against some force or some force may seem to move it. It is said that whatever is happening all around us is the interplay of energy. Energy as a concept is both fundamental and simple and also can be considered as a derived one and more abstract. In Mechanics this is considered as a derived concept from more fundamental concept of force. The connecting link between these two is the concept of work which plays very important part in understanding the interplay of energy occuring all around us. The teaching of this concept is also more challenging because every day meaning of the term work is much different from what we define in science or physics. In what follows we are illustrating the use of simple activities to develop the correct concept of work in pupils; which will also give us an idea as to how to prevent the formation of alternative framework in pupils.

Concepts

i) Work is said to be done only when a force produces motion in an object.

ii) Work is said to be done by (and positive), or against (and negative) the force when the point of application or the object moves in the direction of force or opposite to it respectively.

iii) No or zero work is said to be done if the point of application or the object moves at right angles to the direction of the force.

iv) Amount of work done is directly proportional to a) the magnitude of force, b) the magnitude of the component of the displacement in the direction of the force.

v) Unit of work is erg in C.G.S. and Joule in M. K. S. and is defined as the work done by a unit force in displacing an object through unit distance in the direction of the force.

vi) Although the physical work done by us on an object may be zero the physiological work may not be zero.

Previous Knowledge/Alternative Framework

The pupils know the definitions and units of force and displacement and that they are vector quantities. Pupils may think that if they are holding a bucket full of water for sometime they are doing work on the bucket. They have an intutive concept of energy in the sense that when we are tired we lose energy, machines work at the cost of energy a falling stone increases its energy continuously that is why falling water can be used to produce electrical energy and so on. For this exemplar it is essential to state that they do not know the conceptual relation between force work and energy. If we analyse the every day talk between laymen we can easily conclude that they use these terms to mean the same thing, It is this social usage which feeds the alternative framework of the pupils too.

Presentation

We are arranging our presentation in the form of activities questions and the inference in that order

1. The teacher asks a pupil to move the wall and asks others to observe what happens. Next he asks another pupil to move the table. Pupils observe that the table moves now and earlier the wall did not. Then the teacher asks following questions:

i) Did the pupil apply force on the wall?
Ans:- Yes.
ii) Did the wall move? Ans:- No

In such a situation we say work is not done by the force for in this case the pupil, the teacher states. Similarly the teacher can conclude from the other part of the activity that only when the object moves as a result of the force acting on it the work is said to be done.

2. The teacher asks a pupil to lift his/her bag and then ask him/her to lift his/her friends bag too alongwith his/her own. Ask him to tell what he finds more difficult to the whole class. Following questions can be asked then:

i) When the pupil lifted his own bag how much force was necessary in order to lift it, if mass of each bag is assumed to be M ? Ans. - Mg.

ii) Did this force move the bag? Ans.-yes.

Similar questions can be asked about the activity when the pupil lifts the two bags together. The teacher concludes by stating that the amount of work done is directly proportional to the magnitude of the force.

3. Recalling the experience of the pupils with mopeds used by them or by their relatives or friends, teacher asks the following questions:

i) If a moped containing 1 ltr. petrol runs out of petrol after covering a distance of 40 kilometres, what amount of fuel will be required to travel a distance of 80 kilometers in otherwise similar circumstances ? Ans. - 2 ltr.

With the help of this example the teacher will state that the work done is directly proportional to the displacement. It may be noted here that pupils intuitively understand that the energy stored in the petrol is used to overcome the frictional force in this situation. It may be stated here without proof that if the moped is travelling with constant velocity then the work done by the frictional force and the force applied by the engine are equal but opposite in sigh.

4. Recalling the experience of the pupils regarding pushing and pulling of many objects like almirah, trunk, lawn-mower and so on. the pupils can be made to realise that it is not always convenient to apply the force in the direction of the movement of the object . Insuch a situation, the teacher will explain that the whole of the force is not utilised in the motion of the object but only its component in the direction of motion. This is so because a force can produce change of motion only in its own direction. The other component which is normal to the direction of motion gets balanced by the suitable reaction force such that the net force in the perpendicular direction becomes zero hence the work done in that direction has to be zero. Now the teacher will write the relation of work to force and displacement as equations:

$$W = F.\ S.\ \cos\theta = (F.\cos\theta).\ S = F.\ (S.\cos\theta)$$

Where θ is the angle between force F and displacement S and explain them in words as, the product of force, displacement and the cosine of the angle between the two; the product of the component of the force in the direction of the displacement and the displacement; and the product of the force and the component of the displacement in the direction of the force respectively.

5. By drawing the diagram for uniform circular motion the teacher will explain that in the case the force always acts perpendicular to the small displacement at every time hence the cosine of the angle is zero

so the work done is zero. In other word because force does not produce any change of motion in its own direction and so does no work. Finally he will re-emphasise that the work done by a force can be zero in three independent ways: i) F can be zero. ii) S can be zero and iii) F and S can be at right angles.

6. Lastly to differentiate the difference between the physiological and physical work the teacher will ask a pupil to hold a brick on his hand for or 2 minutes and ask following questions:

i) What is the net force acting on the brick?
Ans:- Zero.

ii) What is the displacement of the brick?
Ans:- Zero.

iii) What is the work done by the force of gravity acting on the brick? Ans:- Zero.

But the pupil will be visibly tired and would feel so and state if asked. Pupils know that getting tired means loss of energy so work must have been done. This internal work done can be termed as physiological work done by the stretched muscles which produce the equal and opposite reaction to keep the brick steady. Whether this work can also be thought of the product of some kind of force and distance will be left to the imagination of the pupils.

Related Higher Knowledge

The expression for work in terms of the scalar product can be explained to some pupils who show interest. The teacher will study the work-energy theorem and learn the relationship between work and energy and think of the ways and means by which this relationship can be explained to the pupils.

Assignments for Pupils

i) Calculate the work done by a worker who lifts a stone through a distance of 0.2 m while applying a force of 220 N on rope making an angle of 45 degrees.

ii) Calculate the work done to push a block of mass 15 kg up a frictionless inclined plane inclined at an angle of 30 degrees.

iii) Solve problem ii) for the case when the coefficient of friction between the block and the plane is 0.2.

iv) Assuming the orbit of the earth around the sun as circular what is the work done by the gravitational force of sun acting on earth for one complete revolution and for any part of the revolution ?

v) Calculate the work done by gravitational force acting on a stone thrown with a velocity of 30 m/s at an angle of 45 degrees to the vertical till it reaches to the topmost position.

Conclusion

We have tried to describe here some activities and questions which can lead to the concept of work and its relationship with force. We have not given here explicitely the relationship of work with energy. In the end we would like just to mention that as force is result of interaction the very existence of force presupposes the existence of some external agency. So we say that the force or that corresponding agency does the work and it is this agency which either loses or gains energy depending on the sign of work. We would very much like that some teachers adopt this strategy of teaching the concept of work and give us feedback on the merits and demerits of the strategy so that we can further modify it.

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Annexure-I

AN APPROACH PAPER

DEVELOPMENT OF STRATEGIES OF TEACHING PHYSICAL SCIENCE AT SECONDARY LEVEL

Dr.V.G.Jadhao,
R.C.E.,Bhubaneswar

Introduction

Teaching of Physical Science in our schools has seen a lot of revision both in its content and method at all levels years. As these content to be covered became every time bigger and bigger due to the ever expanding sphere of knowledge the approach of the science curriculum at the secondary level has travelled a long distance from disciplinary approach of seventies to the science for all approach of the National Policy of Education 1986. This change can clearly be seen if we make a study of the science textbooks prepared by NCERT or curriculum materials produced by the corresponding state agencies. From the textbook point of view or in terms of the pupils although the disciplines like physics, chemistry and biology have been integrated well, the teaching of science is compartmentalised into physical science and biological science for the obvious reason that it takes much longer time to prepare teachers who can handle both physical and biological sciences with equal professional expertise especially when they themselves had done their own schooling through disciplinary approach. What is true for teachers is also true for teacher educators and trainers. It is in this context we are organising this programme for the development of strategies of teaching physical science at secondary level. It is essential in this context to just take a look at the approaches andskills that come to our mind.

Approaches and Skills

Before we list the various approaches and skills relevent to teaching of science it is better to clarify the meaning of the the terms: 'approach', 'skill', and 'method' because we find these terms used to mean more or less the same thing in discussion or sometimes in the literature also. Approach is a very broad term used to emphasize a general idea in the teaching of the wholecurriculum or a major part of it. Method is a term we normally reserve for just one lesson delivered in a classroom. Of course more than one methods are sometimes used; in that case however we make use of the term like lecture-cum-demonstration. Skills are on the other hand the specific behaviours on the part of the teacher used by him for short duration of time during a lesson. It is with this distinction in mind we are listing below a tentative inventory of approaches and skills.

APPROACHES	SKILLS
1. Logical approach	1. Skill of explaining
2. Historical approach	2. Skill of questioning
3. Environmental approach	3. Skill of giving examples
4. Laboratory approach	4. Skill of stimulus variation
5. Process approach	5. Skill of generating curiosity.
	6. Skill of creating a conceptual or cognitive conflict.

Expectations

Strategy is a term borrowed from the military terminology where it means a detailed programme of action involving different equipments and people to achieve a certain objective. Strategy also means the same thing in an educational context. The objective for us is terminal behaviour of pupils showing the acquisation of knowledge skills and applicational abilities. Thus strategy in the context of this workshop means outlining of a judicious choice of approach, skills, content area, needs of the pupils and ability and inclination of the teacher. The ability and the inclination of the teacher is the most crucial and important component of the strategy because he happens to be the sole implementer of the strategy. In view of this fact we are realising the output of this workshop as:

1) Recommendations of the general guidelines for the teacher to be arrived at by proposal and discussions for teaching of physical science taking into consideration the difficulties faced by teachers while teaching in the classroom;

2) Examplars of instructional material to be prepared by the participants on a specific content area by working in a group where the ideas of each membe will be discussed at length and a consensus shall be arrived at in the form of an instructional material.

Methodology and Rationale

For achieving the expectations participants will first identify the difficult content areas and describe the type of difficulty whether conceptual or pedagogical. Regarding the conceptual difficulties we have planned two lectures; one each in physics and chemistry every day in the forenoon. As for the pedagogical difficulties they may findsome place in the discussion with during the lecture sessions but we think they are best taken care of by discussion by teaching As a result of this discussion the group shall develop instructional material in an area chosen by and of interest in the group. In this way it will become possible to incorporate the local resources in the teaching learning process and involve the teachers inthe construction of the pedagogical part of the curriculum. The instructional material will be developed by participants keeping in mind the approaches and skill given earlier. In this exercise the originality of the idea, its practicability and the ability of the group discuss and reach a consensus is very crucial. To help ~~of~~ the participants we are giving here a list of strategies which can help them to produce the material and also arrive at general guidelines for teaching physical science at secondary level.

1) Listing of real life situations outside and inside the classroom related to the topic with a note on its use.

2) Listing of questions which create cognitive or conceptual conflict with a note on how to resolve the conflict.

3) Listing of examples/analogies related to particular concept.

4) Designing of simple experiments or group activities for the pupils to facilitate learning of the concept.

5) Designing of application based problems.

6) Sorting and/or adapting the instructional material from PSSC physics, CBA, modular approach, lectures and exemplars provided by resource persons and other resource materials to local needs of the teachers.

A general format is suggested for development of the instructional material as follows:

I. Introduction: Should be brief and to the point and state the importance of the selected content area in real life or the importance of selected approach or skill for illustration (if you feel you can list the specifice objectives in behavioural terms here).

II. Presentation : A detailed sequential note on how to teach (A separate note onthe related higher knowledge useful for the teacher can also be included in this section).

III. Conclusion: Should be brief and highlight the special feature of the presented on and state its limitation if any.

IV. References if needed.

Conclusion

The overall objective of this workshop is to develop strategies of teaching physical science and at the same time initiate the teachers to become developers of the pedagogical part of the curriculum for better implementation of the strategies.

Annexure II

A DRAFT ON STRATEGIES FOR TEACHING PHYSICAL SCIENCE AT SECONDARY LEVEL

(Prepared by Mr.Madhusudan Mohanty, Dr.P.M.I.A.S.E., Sambalpur and accepted by all participants)

Science has been accepted as a core subject in the school curriculum in all countries of the world. But inspite of the tremendous efforts undertaken at all levels a considerably large proportion of students in our country either do not join the school or drop out after a few years and thus are deprived of science education. Science has many values for which it has received its due place in the school curriculum. Out of these values the most important one is the utilitarian value. Science is recognised by all on this coun The basic knowledge of science has become indispensible in all spheres of life: health, nutrition, sanitation, medicine, agriculture, industry, environment and many others. So whatever science the childrn learn in the school should not be confined to their scholastic achievement in separate disciplines of science but it should be useful to him in future life as a citizen of our nation. This fact has been recognised in the regional meeting on 'Science for All' in Bangkock in September, 1983. It was also endorsed by the Conference of Ministers of Education in 1985. The National Policy of Education 1986 has gonefurther and suggested that science education be imparted to the out-of-school population of children by including it in Nonformal Education curriculum. In other words the science education has to be popularised. We have tothink of som special and new strategies for this purpose. As a resul of the discussion held during this programme and after having worked on preparation of exemplars using these strategies an inventory of the following strategies is recommended:

1. Identifyimg the real life situations related to the concepts in physical science inside and outside the classroom.

2. Listing questions which create conceptual/ cognitive conflict to generate curiosity and to effect better learning.

3. Listing of experiments/analogies relating to a particular physical science concept.

4. Designing of simple experiments/group activities for the pupils to facilitate learning.

5. Integrating/Connecting physical science concepts with those in other school subjects.

6. Relating physical science concepts with work or employment situation in the society.

7. Utilising community resources for effective teaching and for giving science education a community base.

8. Utilising improvised low cost/no cost teaching aids for effective teaching and for taking science from school to the homes.

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ANNEXURE-III

LIST OF PARTICIPANTS AND RESOURCE FACULTY

PARTICIPANTS

1. Dr.Sur Prasad Pati,
Senior Lecturer in Edn.,
College of Teacher Edn.
Bolangir, Orissa.

2. Sri Hrudanand Misra,
Govt.High School,
Unit.I, Bhubaneswar.

3. Sri Minaketan Swain,
Govt. High School,
Unit-I,Bhubaneswar.

4. Sri Purna Chandra Rath,
Asst.Teacher,
R.C.D.High School,
Nowrangpur.

5. Sri Udaynath Sahu,
Asst.Teacher,
Hubback High School,
G. Udaygiri, Dt.Phulbani.

6. Sri Bindu Ch.Patnaik,
Asst.Teacher,
Sri Aurobindo Siksha Niketan,
At/P.O. Kundra,Koraput.

7. Sri Surendra Pattanayak,
Asst.Teacher,
Govt. High School,
At/P.O. Ambaguda,
Jeypore Circle, Koraput.

8. Dr.J.P. Sharma,
Reader in Education,
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9. Smt. Rabipriya Devi
Lecturer in Education,
C.T.E., Angul.

10. Smt. Sneha Prava Panda,
Asst.Teacher,
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Bhubaneswar.

11. Sri Arun Kumar Singh,
D.B.R.K. Jalan Govt. +2
Inter School, Patna,City,
Bihar.

12. Sri Kaushal Kishore Sharma,
Govt. High School,
Gardanibagh, Patna.

13. Sri Arun Kumar,
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(+2), Patna-800 004.

14. Sri B.Ganapati Acharya,
Sadasiba High School,
At/P.O. Dahana,
Dist:- Koraput.

15. Dr.B.B. Panda,
D.A.V.B.Ed.College,
Koraput.

16. Sri Madhusudan Mohanty,
Sr.Lecturer,
Dr.P.M.Institute of
Advanced Study in Edn.,
Sambalpur.

17. Dr.Purnima Das,
Reader in Education,
Nalini Devi Women's
College of Education,
Unit III,Bhubaneswar.

18. Sri Achyutananda Nayak
Lecturer,
A.A. Training College,
P.O. Fakirpur,
Dist:- Keonjhar.

RESOURCE FACULTY (ALL FROM R.C.E., BHUBANESWAR)

1. Dr.V.G.Jadhao,
Programme Director
Reader in Physics.

2. Dr.J.K.Mohapatra,
Reader in Physics.

3. Dr.S.K.Mohapatra,
Reader in Chemistry.

4. Dr.H.H.Tripathy,
Reader in Chemistry.

5. Dr.A.N.Gupta,
Reader in Chemistry

6. Dr.T.J.Vidyapati,
Reader in Chemistry.

7. Dr.B.K.Parida,
Lecturer in Physics.

8. Dr.(Mrs)N.Chhotray,
Lecturer in Chemistry

9. Dr.(Mrs)J.Mohapatra,
Lecturer in Chemistry

10. Mrs. M.Mohapatra,
Lecturer in Physics.

ANNEXURE-IV

EGIONAL COLLEGE OF EDUCATION:BHUBANESWAR

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ELOPMENT OF STRATEGIES OF TEACHING PHYSICAL NCE AT SECONDARY LEVEL FROM 1.9.93 TO 7.9.93.

PROGRAMME

Time	Activity
9.30 - 11.00AM	Registration
11.00- 1.00PM	Inauguration
1.00 - 2.00PM	Lunch Break
2.00 - 2.45PM	Discussion on Approach Paper. (Dr.V.G.Jadhao)
2.45 - 3.00PM	Tea Break
3.00 - 4.00PM	Alternative Framework. (Dr.J.K.Mohapatra)
4.00 - 5.00PM	Teaching of Chemistry. (Dr.A.N.Gupta)
9.30 - 10.15AM	Concept of Force. (Dr.V.G.Jadhao)
10.15-11.00AM	Chemical Bonding I [illegible] (Dr.Mrs. N.Chhotray) [illegible]
11.00-11.15AM	Tea Break
11.15-12.00Noon	Wave Motion (Dr.B.K.Parida)
12.00-1.00PM	Identification and Discusion on Topics selected by Participants.
1.00 -2.00PM	Lunch Break
2.00 -2.45PM	Chemical Bonding II (Dr.T.J.Vidyapati)
2.45 -3.00PM	Tea Break
3.00 -3.45PM	Teaching of Light. [illegible] (Mrs.M.Mohapatra)
3.45 -4.30PM	Structure of Atom. (Dr.H.H.Tripathy)
4.30 -5.00PM	Discussion on strategies of Teaching. (Dr.V.G.Jadhao)
9.30 - 10.15AM	Concept of Mole (Dr.S.K.Mohapatra)
10.15-11.00AM	Carbon and its compounds. (Dr.Mrs. J.Mohapatra)
11.00-11.15AM	Tea Break
11.15-12.00Noon	Energy changes in chemical Reaction. (Dr.A.N.Gupta)
12.00-12.45PM	Formation of groups and allotment of topics.
[illegible].00 -2.00PM	Lunch Break

	2.00 - 2.45PM	Discussion on Format of the write-up.
	2.45 - 3.00PM	Tea Break
	3.00 - 5.00PM	Group Work
4.9.93 Saturday	9.30 - 11.15AM	Group Work
	11.15- 11.30AM	Tea Break
	11.30- 1.00PM	Group Work
	1.00 - 2.00PM	Lunch Break
	2.00 - 2.45PM	Group Work
	2.45 - 3.00PM	Tea Break
	3.00 - 5.00PM	Presentation of some example by different groups for feedback from all in general session.
5.9.93 Sunday	9.30 - 11.15AM	Group Work
	11.15-11.30AM	Tea Break
	11.30-1.00PM	Group Work
	1.00 - 2.00PM	Lunch Break
	2.00 - 2.45PM	Group Work
	2.45 - 3.00PM	Tea Break
	3.00 - 5.00PM	Group Work
6.9. Monday	9.30 - 11.15AM	Presentation of Group Work in general session.
	11.15- 11.30AM	Tea Break
	11.30-1.00PM	Presentation of Group Work in general session.
	1.00 - 2.00PM	Lunch Break
	2.00 - 2.45PM	Presentation of Group Work in general session.
	2.45 - 3.00PM	Tea Break
	3.00 - 5.00PM	Presentation of Group Work in general session.
7.9.93 Tuesday	9.30 - 10.30AM	Finalisation of the general guidelines about the strate
	10.30- 11.15AM	Finalisation of the Group reports.
	11.15-11.30AM	Tea Break
	11.30-12.30PM	Finalisation of the Group reports.
	12.30- 1.00PM	Evaluation
	2.00 - 5.00PM	Valedictory and disbursemen of TA and DA.

Jadhao

(V.G. Jadhao)
Programme Direc

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